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GRAIN IS BEING CARRIED from Chicago to New York, all-rail, for 10 to 12 cts. per 100 lbs., according to the "Financial Chronicle." This eclipses even the 16 cts. per bushel rate from Chicago to Liverpool, which was mentioned by Mr. Thos. C. Clarke, in his contribution in our issue of March 31. Taking the distance from Chicago to New York at 1,000 miles, it is seen that 10 to 12 cts. per 100 lbs. for a haul of this length is equivalent to only 2 mills to 2.4 mills per ton mile. But it is also stated that even this low rate includes a charge of 3 cts. per 100 lbs. lighterage in New York harbor, making the total rate for the railway haul from Chicago to New York only 7 to 9 cts., or 1.4 mills to 1.8 mills per ton mile. We know of no lower rate than this having ever been made for railway freight transportation, and the puzzling thing is that railway traffic managers should accept business at such figures, which must be well below the actual cost to the railway company, so that it could actually show a better balance-sheet at the end of the year by refusing the shipments.

SIX COMPOUND CONSOLIDATION PUSHER LOCOmotives have been built by the Baldwin Locomotive Works for the Allegheny Mountain division of the Norfolk & Western R. R. They are two-cylinder compounds, designed by Mr. W. H. Lewis, Superintendent of Motive Power. The general dimensions are as follows:

Driving wheels, diameter	4 ft. 8 ins.
Weight on driving wheels	165,550 lbs.
Weight, total	185,550 "
Cylinders	23 × 35 × 32 ins.
Boiler (wagon top), diameter	5 ft. 8 "
Boiler pressure	200 lbs.
Firebox	10 ft. 2 ins. × 3 ft. 1½ ins.
Tubes (306), diameter	2¼ "
Heating surface	2,796 sq. ft.
Capacity of tender tank	4,000 gallons.
Capacity of coal space	8 tons.

GERMAN RAILWAY STATISTICS, for 1896-97, are published in the "Centralblatt dex Bauverwaltung," for April 6, 1898. The total length of track in operation, in 1897, was 28,626 miles of standard gage, and 817.5 miles of narnow gage. During the year there were 487 derailments and 281 collisions; and in these accidents 762 persons were killed and 1,969 wounded. These figures, for accidents, which probably include all casualties in switching and coupling cars, show an increase over previous records.

ELECTRIC RAILWAYS IN EUROPE have a total length of 914.6 miles, and they operate 3,100 motor cars. The trolley system very largely predominates, as there are 122 roads of that type, and 8 with underground conductors; 7 with a central rail, and 14 worked by accumulators. Germany operates 398.5 miles out of this total, and France comes next with 173.2 miles. England has 68 miles, and Italy has 71.7 miles; while the remainder is distributed over other European countries. Switzerland is only credited with 48.8 miles.

THE RAILWAYS OF EUROPE had an aggregate length of 159,025 miles at the beginning of 1897, according to statistics recently published. This was an increase of 3,144 miles over 1896, the principal increase being 806 miles in Austria-Hungary, and 579 miles in Germany. Allowing about 3,000 miles for construction during 1897 would bring the present mileage up to 162,000 miles, or nearly 20,000 miles less than the mileage of the United States. The lengths of railways in the principal countries of Europe in the early part of 1897 are given as follows:

	Miles.
Germany	29,355
France	25,089
Russia (exclusive of Trans-Siberian Ry. and Trans-Caucasus Ry)	22,455
Great Britain and Ireland	21,217
Austria-Hungary	18,951
Italy	9,439
Spain	7,615
Sweden	6,073
Belgium	3,582
Switzerland	2,200
Roumania	1,784
Holland	1,608
Denmark	1,605
Turkey and Bulgaria	1,507
Finland	1,484
Portugal	1,451
Norway	1,201
Greece	590
Servia	335
Luxemburg	269
Islands of Malta, Jersey and Man	68

THE ELECTRIC STREET RAILWAY SYSTEM OF Dublin, Ireland, which has just been put in operation, is of considerable interest to Americans, owing to the fact that all the machinery and equipment was shipped from the United States. The steel work for the boiler house, 131 × 76 ft., was furnished by Riter & Conley, of Pittsburg, Pa. Twenty Babcock & Wilcox boilers and two Green economizers were supplied by the respective companies, while all the valves and piping were made by the Crane Co., Chicago, Ill. "Stratton" separators, "Hunt" coal conveyors, "Wheeler" condensers and boiler feed pumps; and Reynolds-Corliss engines, built by the E. P. Allis Co., Milwaukee, Wis., are also included. The 500 K-W. generators were manufactured by the General Electric Co., as were also the car motors. The trolley wire, feeders, etc., came from John A. Roebling's Sons & Co., and the trucks from the Peckham factories. The capital stock of the company is said to be $1,200,000.

THE NORTHERN TRUNK LINE RAILWAY OF SWEden is to be extended to Ofoden, on the Arctic Sea, by late vote of the Swedish Riksdap. The railway follows generally along the shores of the Gulf of Bothnia, from Stockholm to Lulea, near the boundary between Sweden and Norway. It passes the mines of Gellivara, rich deposits of iron. The projected terminus of Ofoden is in Norway, close to 69° N. latitude, and on a harbor open at all seasons.

THE STATE RAILROAD COMMISSIONERS will hold their tenth annual convention at the office of the Interstate Commerce Commission, Washington, D. C., on May 10. Committees appointed at the last convention will report on the following subjects: 1. Classification of Construction Expenses. 2. Classification of Operating and Construction Expenses of Electric Railways. 3. Railway Statistics. 4. Uniform Classification. 5. Powers, Duties and Work of Railroad Commissions. 6. Legislation. 7. Delays Attendant upon Enforcing Orders of Railroad Commissioners. 8. Safety Appliances. Addresses will be made by prominent railway men. Members are asked to suggest topics for consideration. These should be addressed to Hon. James W. Latta, chairman committee on program, Harrisburg, Pa.

NO SERIOUS RAILWAY ACCIDENTS have been reported in the newspapers this week. This may be due to the large amount of war news, causing the exclusion of much of the matter usually published by the daily papers.

A BOILER EXPLOSION at Pleasureville, Ky., on April 23, killed four men and injured one. It is said that the victims were blown 75 ft. in the air.

A DISASTROUS TORNADO occurred on May 3 at Jericho, Cedar county, Mo., which resulted in the death of 13 persons and the fatal injury of several others. Other towns in the vicinity were also damaged.

ANOTHER POWDER MILL EXPLOSION is reported to have occurred on April 28, at Dover, Morris county, N. J., resulting in the death of six men and the serious injury of four others. The works consist of a number of isolated buildings used for the different operations. The first explosion, it is thought, occurred in one of the packing houses, caused by a spark from the pipe of a careless smoker. Sparks and burning timbers from this building fell upon the others, which caught fire, and their contents exploded. Large quantities of explosives manufactured for the government were destroyed, the shock being felt 25 miles away.

THE IMPORT OF SICILIAN SULPHUR is being interfered with by the existing war with Spain, and the stoppage in the supply of this material is being seriously felt by the papermakers of the United States. In 1897 about 118,137 tons of sulphur came to this country from Sicily, mostly from the port of Palermo. As Spain has classed sulphur among the articles contraband of war, the price has risen in one month from $22 to $40 per ton. As sulphur is largely used in the manufacture of the cheaper grades of paper used by the daily journals, a marked increase in the price of this paper may have a compensating effect in discouraging the issue of twenty or more "war extras" per day by some of our yellow journals.

"RAPID FIRE," OR "QUICK-FIRING" GUNS are frequently referred to at this time, but few laymen really appreciate the meaning of the term, as contrasted with the "slow-fire" breech-loader. The distinction is not one of size, for the rapid-fire system has extended from 1-pdr. projectiles to 4-in., 5-in. and 6-in. guns, throwing 36, 70 and 100-lb. shot or shell. The essential difference is in the method of loading. Instead of opening the breech and inserting the projectile and the powder separately, the latter in a bunting bag, ammunition for rapid-fire guns is now prepared as for small arms; the ball, powder and firing primer are united; the powder in a metallic case attached to the shot, and the primer in the center of the base of this case. There are a number of types of rapid-fire guns, differing in the way this fixed ammunition is fed to the gun and fired. The 6-pdr. (2.24-in. caliber) rapid-fire guns of the Hotchkiss, Driggs-Schroeder, Maxim-Nordenfeldt and Sponsel types, can discharge 100 shots in 4m. 26s., 4m. 35⅛s., 4m. 41s., and 4m. 56½s., respectively; or 20 to 25 shots per minute with accuracy of aim. Without attempt at accuracy of aim the rate can be increased to 30 to 35 shots per minute. With 5-in. rapid-fire guns, or 70-pdrs., 36 shots have been fired in 5 minutes.

THE STEAM YACHT "WINDWARD," employed in the expedition to Franz Josef Land in 1894, was, on May 3, formally presented to Mr. R. E. Peary, C. E., U. S. N., by Lieut. A. B. Armitage, representing Mr. Alfred Harmsworth, her former owner. The presentation took place at a luncheon at the Holland House, in New York. The "Windward" is to be used by Mr. Peary in his next expedition, and is now on her way to the North with supplies. She is 45 days out from this port, but Lieut. Armitage expresses no fears as to her safety.

A SPEED OF 580 KNOTS IN A SINGLE DAY was made by the North German Lloyd steamship "Kaiser Wilhelm der Grosse," on her last trip from Bremen and Southampton to New York. This exceeds the best previous record for a 24-hour run by 14 knots.

THE CARACAS SAMPLE WAREHOUSE, established in Venezuela by the National Association of Manufacturers, of the United States, was formally opened on March 29 in the presence of President Andrade, of the United States of Venezuela, members of the Cabinet, and foreign representatives. Speeches were made by President Andrade, General Ybarra, U. S. Minister Loomis and Mr. R. Dolge, Special Commissioner to Venezuela from the Association; and all expressed great faith in the mutual benefits to arise from an increased exchange of products and manufactures. Over 60 American firms already have goods on exhibition in the sample warehouse; and the names include some of the most prominent manufacturers in the United States. The Secretary of the Association is Mr. E. P. Wilson, Cincinnati, O., and the Association publishes a journal, called "American Trade," at 48, 51 Bourse, Philadelphia, Pa., which gives the full detail of the opening of the Caracas warehouse, and other matters of interest.

ELECTRIC LIGHTING OF THE CITY OF MEXICO, will, by March 1, 1899, be accomplished by modern machinery. According to reports a contract has been closed with the Westinghouse Electric and Manufacturing Co., Pittsburg, Pa., for twenty 300-HP. two-phase generators wound for 440 volts and the necessary transformers and switchboard. The machinery will be used in connection with the San Ildefonso-Tlalnepantla water-power transmission line which will employ a pressure of 22,000 volts to transmit current into the city, where substations and transformers will step it down to commercial voltages.

MUNICIPAL TRADING IN ELECTRIC LIGHTING fixtures has been declared to be beyond the powers of municipal corporations in England in the absence of legislative authority to that effect. The question arose, according to the London "Surveyor," at Leicester, where the town brought action to recover some $25 from a tradesman to whom it had sold lamps and other fittings. The court decided that since the goods had been furnished they must be paid for, but that the plaintiff should bear the costs, and had clearly exceeded its powers. The town did not restrict its trade to patrons of its lighting plant, which might have altered the case, especially the supplying of lamps. The reasoning used in this decision would doubtless hold good this side of the water, though the sales coming to our attention are generally small and principally as a matter of accommodation, being of sewer and water pipe and similar materials.

AN AMERICAN SYSTEM OF BICYCLE STORAGE.

We illustrated and described in our issue of March 31 a plan of a building for bicycle storage which was awarded first prize in a competition instituted by the German Society of Engineers and Architects. Since that time our attention has been called to the fact that an American system of bicycle storage enables at least three times as many machins to be stored in the same floor space, and at the same time all are perfectly accessible. The rapidly increasing transportation of bicycles on railways has made absolutely necessary some system of storage which will afford facilities for the quick handling of wheels, will permit packing the largest number in the smallest space, and at the same time provide against damages to the wheels from contact with each other. The Westcott-Jewell system, here illustrated, applies to storage in railway trains, homes, bicycle factories, riding schools, general factories, clubs, schools, etc.

FIG. 1.—A NEW STORAGE SYSTEM FOR BICYCLES.
The Westcott-Jewell Co., Seneca Falls, N. Y., Manufacturers.

In general terms, this system provides storage for three wheels in a single tier, or for six wheels in a double tier, for every 40 ins. of floor space against the wall. But if the room is large enough to admit of a double section, 12 ft. wide, running through the middle of the floor, 12 wheels can be stored for each 40 ins. of floor length. Thus, in a space 50 ft. long by 12 ft. wide, in the centre of a room, 180 bicycles can be safely and conveniently stored. And if the side walls can also be utilized, as in a room 55 ft. long and 35 ft. wide, 360 bicycles can be stored.

The method by which this is accomplished is illustrated in Fig. 1. It will be seen that the track for the central wheel in each group of three is raised above the two on either side, so that the handle-bars come above and do not interfere with the others. This method of storage of wheels has been applied at the Grand Central Station, New York city, to a storage room for 500 wheels, and it is also in use at the Hotel San Remo, the Windsor Hotel, the new Pope Building, at Washington, D. C., and many other places.

Besides the appliances shown in Fig. 1, the Westcott-Jewell Co. makes a specialty of various other appliances for holding bicycles, of which perhaps the most interesting is a holder for carrying wheels in the front and rear of electric cars, as shown in Fig. 2, which is from a photograph of a car of the Nassau R. R. in Brooklyn.

The manifest advantages of this system to city bicycle riders who wish to reach country roads without a long ride over stone pavement are evident. Whether the street railway companies will see a profit in the idea is not so clear. It would probably be easy at the start to collect a 10-ct. fare for a wheel; but if the plan became generally adopted, one can foresee the rise of a popular demand, enforced by municipal or legislative enactment, that bicycles shall be carried free on electric railways as they are on steam railways. Moreover, occasional collisions with wagons and trucks, and the resultant bills of damages for squushed bicycles might eat into the profits from carrying them.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Double Use of Streets.

The consent of the abutting property owners and of the local authorities to the construction and operation of one street railroad is not sufficient to authorize the use of such tracks by another company for the operation of its road, even though the first company acquiesces, but such consent must be obtained for the operation of the second road. Colonial City Trac. Co. v. Kingston City Ry. Co., 47 N. E. Rep. 810.

Liability for Misrepresentation of Engineer.

The statement of a competent hydraulic engineer as to the daily fall of water from certain sources, in reliance upon which a city purchases a water-works plant, may, if false, be made the basis of an action of deceit. Tacoma v. Tacoma L. & W. Co. (Sup. Ct. Wash.), 50 Pacific Rep. 55.

Assignment of Franchise.

The franchise or privilege granted by a city to a corporation and its assigns to erect and maintain poles and electric wires in its streets may be assigned in the absence of any statute upon the subject, as the rule that the grantee of a public or quasi-public franchise cannot assign or sell the same does not apply. Commercial L. & P. Co. v. Tacoma (Sup. Ct. Wash.), 50 Pacific Rep. 592.

Right to Enforce Public Contract.

A bidder for a public contract, to be entitled to enforce the award to himself, must show that he is the party with whom the contract should be made, regardless of the rights of anybody else; and he cannot rely on the weakness, informality, or irregularity of the bids of others, or of proposed irregular action of the public body with reference to anybody else. Bryce Furnace Co. v. Toledo, 7 Ohio Dec. 338.

Withdrawing Bid for Mistake.

A bid for public work may be withdrawn by the bidder when it contains mistakes made by the engineer of the bidder, and is repudiated as soon as read, and before action has been taken upon it. For a bidder for the work of a municipality should not be held to the strict letter of his agreement, where he would be released if dealing with an individual. Moffett v. Rochester, 30 C. L. N. 11.

Liability on Acceptance of Defective Work.

The members of a corporation who proceed to construct a bridge as individuals or co-partners, and so conduct their business as to cause one from whom they purchase materials to believe that they are doing the work as individuals and partners, and not as a corporation, and who receive credit as individuals, are personally liable, notwithstanding their incorporation. Rust-Owen Lumber Co. v. Wellman, 72 Northwestern Rep. 89.

Damage to Gas Pipes in Houses.

The fact that a company makes no examination of its gas pipes on premises into which they run raises no presumption of negligence in the absence of cause for examination.—State v. Consol. Gas Co. (Supr. Ct., Md.), 37 Atlantic Rep. 263.

THE MUNICIPAL WATER-WORKS OF THE CITY OF DULUTH, MINN.

By W. B. Patton, Ex-City Engineer.*

The City of Duluth, Minn., is situated at the western extremity of Lake Superior, in latitude 46° 45' N. and longitude 92° W. It lies on the northerly shore of the lake, and of St. Louis Bay and River. Its greatest length is parallel with the lake, and is about 25½ miles; its breadth is irregular, being at its maximum about six miles. The total area of the city is 67½ sq. miles.

The city proper lies about midway of the length of the incorporate area, which includes, on the east along the lake shore, the former City of Lakeside, a residence suburb; on the west, along the bay and river of St. Louis, the former City of West Duluth and the village of New Duluth, manufacturing centers; and at the head of navigation of the St. Louis River, the old village of Fond du Lac, one of John Jacob Astor's trading posts, and the point at which the old-time trappers and voyagers landed, to make the portage around the Dalles of the St. Louis River. The present population of the entire city is estimated at 60,000.

Geologically, Duluth is a very ancient place, the rock formation being granite (syenite), gabbro, sandstone and trap, of the Taconic series. The sandstone outcrops at the western limits of the city, the granite and gabbro, with trap dikes, occupy the central portion, and the traps of the copper-bearing series, the eastern. The soil is a tenacious red clay, with occasional beds of gravel and sand. The points of land, running out into the lake and bay, are composed of shingle and sand cast up by the lake.

Topographically, the rock outcrop rises abruptly from the lake, along the entire shore, to a height of from 15 to 30 ft.; and along the bay and river, clay banks rise to a height of from 30 to 40 ft., increasing to 60 ft. at New Duluth. From the level of these banks the ground rises gradually, for some distance back, the rate of rise being much less in the eastern and western portions of the city than in the central or business section; as the distance from the lake increases the slope of the ground becomes steeper, until an elevation of about 600 ft. above the level of the lake, or about 1,200 ft. above sea level, is reached. In the central portion of the city this elevation is attained about 4,000 feet from the lake shore.

Above the 600-ft. contour, which is practically the edge of the Lake Superior basin, the character of the ground changes entirely, for while it still

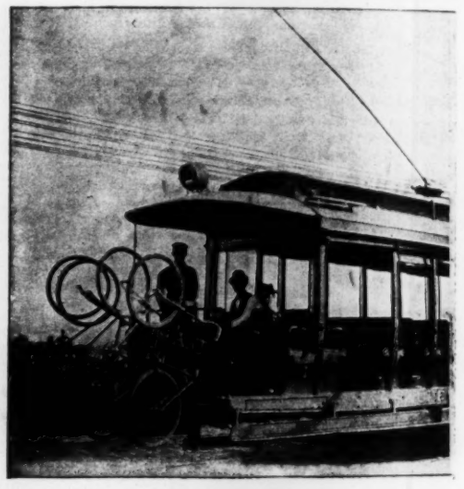


Fig. 2.—Rear View of Electric Car Fitted with "Railroad" Hangers for Carrying Bicycles.

rises toward the west, the grades are more gradual and irregular, being cut up with creek valleys and hills, making a very diversified landscape; some of the hills reaching to a height of over 800 ft. above the lake level.

Minnesota Point (seven miles long), Rice's Point (1¼ miles long), and the level ground between them, on which are situated the railroad yards, docks, elevators, wholesale houses, etc., are but a few feet above the level of the lake.

The numerous creeks, which flow from the plateau at the top of "the hill," have cut, in the side hill, deep and wide ravines, some of which are rarely picturesque and of romantic beauty, and are utilized by the city as parks. Occasionally "points of rocks" project at right angles to the hill side, deflecting the general trend of the contours and necessitating heavy grades and rock cuts on some of the streets.

As a rule the city proper is platted on the rectangular system, the streets being laid out parallel with the general direction of the contours, the avenues crossing at right angles. Consequently, the grades on the streets are light, except where they cross one of the creek valleys, or pass over one of the "points of rocks"; while the avenues are steep and, near the top of the hill, have in some cases grades that are impracticable for highway purposes.

*Palladio Building, Duluth, Minn.

Water Supply.

Up to and including the year 1883, when the population was 5,000, the city depended for its water supply on private wells, and on lake water, peddled in wagons, which were filled, by hand pumps, from the shore waters of the lake. As a natural consequence, typhoid fever was a frequent visitor, the deaths from this cause, in 1883, being at the rate of 300 per 100,000 inhabitants. During this year a contract was entered into between the then Village of Duluth and the Duluth Gas & Water Co., for the construction of water-works for domestic supply and fire service, and also for a gas plant for public and private lighting. Work was begun immediately upon the building of the plant, and it was soon finished and tested. The water plant consisted of an intake of 18-in. pipe, extending 480 ft. into the lake at Fifteenth Ave., East, a point which is a trifle over one mile from the city hall; a pump house with two 1,000,000-gallon duplex, Blake pumps; a small covered masonry reservoir, at Tenth Ave., West, and First St., the western end of the system, and at an elevation of 234 ft. above the lake; and a distribution system of small diameter wrought-iron pipe, treated by the Kalamein, or some similar process, which make of pipe was found to be unsatisfactory and has been almost entirely replaced with cast-iron.

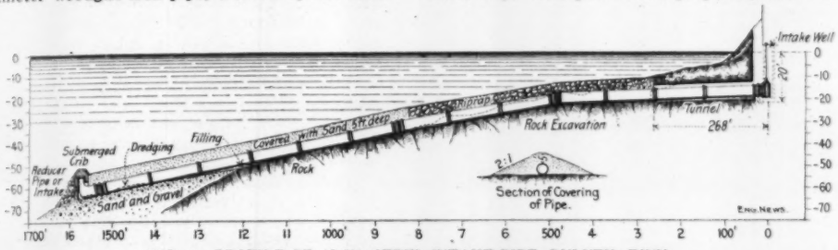


FIG. 1.—PROFILE OF 42-IN. STEEL INTAKE PIPE, DULUTH, MINN.

(Since the above cut was made we have learned that instead of placing sand and gravel over the pipe, as shown, anchor cribs were used, as stated in the text.)

The entire system has been practically rebuilt, as the city grew and the demand for water increased. The point of intake has been maintained at the original location, but a new 20-in. intake pipe has been laid. The pumping capacity has been increased to 9,000,000 gallons; an open reservoir of about 4,500,000 gallons capacity has been constructed at an elevation of 285 ft. above the lake; and a 20-in. force main has been laid between the pump house and reservoir, and a 16-in. supply out of the reservoir. The system has now about 35 miles of mains ranging from 4 to 20 ins. in diameter. The present consumption is between 4,000,000 and 5,000,000 gallons per day.

The location of the intake of this plant has been a prolific source of trouble. When the location was originally decided upon, the surrounding territory was practically unpopulated for some distance west, and entirely so to the east; but the growth of the city eastwardly has been very rapid, and as early as 1888 a sanitary sewer was found to be necessary, and was constructed in Fourteenth Ave., East, discharging into the lake about 500 ft. west of the intake, and in 1889 a combined sewer was built in 18th Ave., East, discharging about 1,500 feet east of the intake.

The Duluth Gas & Water Co. realized that it was necessary to remove the intake further east, and in 1892 had plans prepared, and secured land for a new intake at Lester River, about four miles east of the present location, but nothing was ever done toward the construction of the work.

There has been, for a number of years, great dissatisfaction felt as to the sufficiency of the fire protection furnished by the water company, and as to the purity and wholesomeness of the water supplied; and there has grown up a very strong public sentiment in favor of municipal ownership.

In 1892, Mr. E. H. Keating, M. Am. Soc. C. E., then city engineer, was instructed by the city council to investigate the possible sources of water supply and to prepare plans for a supplementary system of water-works, with particular regard to supplying those portions of the city not then supplied by the water company. In compliance with these instructions, Mr. Keating made an exhaustive study of the various proposed sources of supply, and recommended that the intake and pumping station be located on the shore of Lake Superior, at Brighton, a point about six miles east of the city hall; and the water pumped through a 36-in. main into a reservoir of about 5,000,000 gallons capacity, adjoining the reservoir of the Duluth Gas & Water Co. The district above this reservoir was to be supplied by pumps, at the reservoir, pumping through a 24-in. main into a middle level reservoir, at an elevation of 525 ft. above the level of the lake; the high level, above this reservoir, was to be supplied from the middle level reservoir by pumping into a tower. Mr. D. A. Reed, who followed Mr. Keating as city engineer, elaborated and detailed the system, as proposed by Mr. Keating, and the plans so prepared were described in Engineering News of April 19, 1894.

No work of construction was done under these plans, and the matter remained in abeyance until after the election of Sept. 24, 1895, when, by a large vote, it was decided to issue $1,856,000 in bonds for the purpose of building a municipal water and light plant. The city council at once ordered the writer to prepare plans for an independent system of water-works covering the entire city. The plans were prepared, but it was not until Sept. 15, 1896, that $1,106,000 of the bonds were sold and the carrying out of the project was assured.

The plans, so far prepared, and to be described in this article, cover all of the city proper, east of 34th Ave., W., and the former city of Lakeside.

Districts.

Owing to the great difference of elevation to be overcome, over 800 ft., the city has been divided into three districts, namely: the low level district, embracing all the territory which can be supplied by lifting the water to an elevation of 290 ft.; the middle level district, all of the territory above the low level district which can be supplied by a reservoir at an elevation of 565 ft.; and the high level district, all the territory above the middle level district, it being necessary to subdivide this last district, in order to reach the detached and extremely high sections. The boundaries of all the districts are so arranged, with regard to the elevation of their service reservoirs or tanks, that effective fire streams can be secured from the hydrants in each district without the use of steam fire engines.

Low Level District.

Intake.—The intake is situated at Lakewood, on the north shore of Lake Superior, at a distance of about eight miles east of the city hall, and about two miles east of the site formerly selected, at Brighton.

The quality of the water to be obtained at this point is excellent, incomparably better than at the intake of the water company, and fully equal to normal Lake Superior water. The temperature of the water varies but a few degrees the year around, being 40° F. in the middle of the summer season. The intake pipe, shown in profile by Fig. 1, is of ⅜-in. riveted steel, 60 ins. in diameter, made in sections 116 ft. in length. The sections are joined, under water, by means of rigid and flexible joints, made tight by means of a calking of lead, shown by Fig. 2. Four flexible joints are used, one being at the junction of the pipe with the well, one at the submerged crib, at the end of the intake pipe, and the remaining ones at the changes of grade. The pipe extends from the intake well into the lake a distance of about 1,500 ft., the end being provided with an elbow turned up so as to take water about 11 ft. above the bottom of the lake. The elbow is protected, and the water entering it screened, by means of a submerged crib, Fig. 3. The area of the spaces between the bars of the screen is ten times that of the pipe. The crib rests on the bottom of the lake in 67 ft. of water. The pipe enters the intake well 20 ft. below the level of the lake and is provided, inside of the well, with a 60-in. Eddy double parallel seat valve, with gearing, standard, handwheel and index. For about 814 ft. from the shore, the pipe is laid in a trench excavated in the rock bottom. For a distance of about 225 ft. from the shore the rock was excavated by tunneling and the pipe was laid in the tunnel. Beyond the rock trench, the pipe rests on the bottom of the lake, which is properly leveled up to receive it. As originally planned, the entire length of the pipe was to be covered with 5 ft. of sand and gravel, protected with riprap for the distance of about 590 ft. beyond the end of the tunnel, to a point where the top of the covering is 25 ft. below the surface of the lake.

Later and further investigation seemed to indicate that the disturbance from wave action extended to much greater depths than was at first supposed, and it was doubtful if the sand covering could be maintained or the pipe prevented from shifting. It was, therefore, decided in place of the sand to use saddle anchor cribs over the pipe. Five of these were placed, equally distant, between the end crib and the point where the pipe left the rock cut. The cribs were loaded with broken rock; the covering rocks were specified to contain from 60 to 80 cu. ft. The cribs were paid for as extra work at $1,000 each, a deduction from the contract price being made for the discarded sand filling.

The intake pipe was manufactured by the S. Freeman & Sons Manufacturing Co., Racine, Wis., the cost being $9.11 per ft. for the pipe, delivered on the skids; for the rigid joints, $82 per piece; and for the flexible joints, $398.25 per piece. The pipe was laid by King & Steele, of Duluth, Minn., at a contract price of $32,000, which includes all rock work, laying pipe, covering with sand, riprapping and placing submerged crib over the end of the pipe.

The intake well is 20 ft. in diameter, and 20 ft. deep below the lake level. It is excavated in rock and lined with a 24-in. wall of extra, hard burned, sewer brick laid in Portland cement mortar, two parts of sand to one part of cement. The brickwork is backed up to the surrounding rock by American cement concrete well rammed into place. In the well there will be provided a double set of copper screens with ¾-in. mesh. The well was excavated and constructed by the city, by day's work.

Power House.—The pump house and boiler house above the foundations are constructed of brick, with sandstone basement walls, the stone facing being rock-faced ashlar work. Every other stone in each course is a header. All stonework is laid in Portland cement mortar, two parts of sand to one part of cement. The brickwork is of red pressed brick laid in American cement mortar. The interior faces of the pump house walls are laid to the height of the window sills with red brick laid press brick style. White brick are used above the window sills. The roofs are covered with slate and are supported by steel trusses with riveted connections. The main pump room is 56 × 94⅓ ft. in the clear, with a basement story of 20 ft. in height and a main story of 40 ft. This room is provided with a traveling crane of 20 tons capacity for use in erecting and overhauling the pumps, the crane being supported on girders resting on steel columns built into the walls. The walls of the pump house are carried around the intake well, and the room over the well, on a level with the main floor, is designed for use as a machine shop.

The engineers' office and private room are provided for in the tower, which is constructed on one corner of the building. The building will be heated with steam and lighted with electricity. The building is designed for two 5,000,000 and two 10,000,000-gallon pumps and an engine and dynamo for electric lighting.

The boiler house is 46 × 70 feet in the clear, with a height of 24 ft. to the bottom chord of the roof trusses, and is designed to accommodate two bat-

teries of three boilers each. The capacity of each battery is sufficient for 10,000,000 gallons pumpage, with a reserve of one-third. The north front of the building is a temporary one, as it is intended that this end will be torn down when it becomes necessary to add more boilers. The power house is now under construction, by contract, at a price approximating $33,000. The chimney is of the self-supporting steel type, of an internal diameter of 66 ins. and a height of 150 ft.

The coal switch will be brought from the Duluth & Iron Range Ry. tracks, about 32 ft. above the floor of the boiler room, and extend along the easterly wall of the boiler house. Opposite each boiler, a bin will be built, similar in construction to an ore dock pocket, so as to deliver coal, by gravity, into the boiler room. The space under the bins is for the storage of fuels for use in any emergency, preventing the regular delivery of coal to the bins.

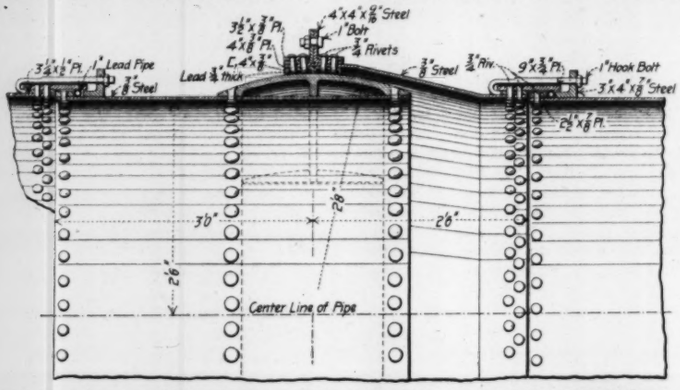


FIG. 2.—DETAILS OF FLEXIBLE AND RIGID JOINTS ON 42-IN. STEEL INTAKE PIPE.

Pumps.—The engines are vertical, triple expansion, condensing, each cylinder being connected to and acting directly upon a single-acting plunger pump. Each cylinder and pump is supported by a separate frame resting upon an individual base. Each cylinder is connected to the main shaft through connecting rods and cranks, set at angles of 120°. Each shaft carries two 20-ton fly-wheels.

The shafts are supported by main bearings 14 ins. in diameter and 22 ins. long, supplied with removable spherical cast-iron shells lined with Magnolia metal. The shells can be taken out at any time by lifting the shafts sufficiently to remove the weight from the bearing.

The steam cylinders are 25½, 43 and 66 ins., respectively, with 54-in. stroke, and will run at 25 revs. per min. at full load, giving a piston speed of 225 ft. per min., provision being made to increase this speed 25% when required.

The valve motion is of the Corliss type, the valves being placed in the cylinder head to reduce the clearance to a minimum. The high pressure valves are controlled by a governor, and the intermediate and low pressure valves by an adjustable cut-off mechanism, operated from the starting platform on the main floor. The low pressure valves being long and heavy, are operated from both ends, there being a complete set of wrist plates and rods on each side of the cylinder, the valves being divided in the center to compensate for slight differences in the lengths of the rod. The low pressure exhaust valves are controlled by separate eccentrics.

The air pump is direct connected, 32 × 12 ins., and driven by back levers from the low pressure pump rod. The condenser is of the jet type. The boiler feed pump is attached to the air pump and driven from the same back lever. It is of the plunger pattern, 3½ ins. in diameter by 16-in. stroke.

Each steam cylinder has a piston rod 5¾ ins. in diameter, which, as well as the crank pins, cross heads and pump rods is of mild open-hearth forged steel. The intermediate crank pin, 12 × 10 ins., is shrunk into one crank and works in a compensating brass block in the other, thus preventing slight inaccuracies in alinement from causing the pins and journals to heat. All connecting rods are made of reworked hammered iron with marine ends, forked at cross head. The shafts, 16 ins. in diameter, are of the same material. Steam will be taken at a pressure of 130 lbs. at the high pressure cylinder and reduced to 6½ lbs. at the terminal. Cylinders are steam jacketed, the high pressure at boiler pressure, and the others reduced.

Two receivers are provided between the cylinders, each supplied with reheating pipes. Both cylinders and receivers are lagged with steel plates and mineral wool. The throttle valve in the main steam pipe, as well as pass overs, cylinder cut-offs, injection water and charging valves are operated from the main floor at the high pressure end of engine and with all gages in sight.

The pumping end of the engines consist of three single-acting, outside packed, plunger pumps, each plunger 18 ins. in diameter by 34-in. stroke. Each plunger is connected to the cross head of its steam cylinder by four open-hearth steel rods, each 4½ ins. in diameter. The stuffing boxes and glands are bushed with bronze. The valve plates are cast independent of the water chambers and are removable. Each pump is provided with 24 suction and the same number of discharge valves, each of hard rubber and annular in shape, giving a combined area 25% in excess of that of the plunger. The work of each pump is to elevate 6,300,000 gallons 290 ft. above the level of Lake Superior in 24 hours. The duty to be developed is 121,700,000 ft.-lbs. for each 1,000,000 heat units. The engines and pumps will be 50 ft. high and occupy floor space 18 × 29 ft.

The pumps and engines were built by the D. Clint Prescott Co., of Duluth, after the plans of J. C. Slocum, M. E., of Duluth; M. Coryell, M. E., of New York, Consulting Engineer, and T. W. Hugo, M. E., of Duluth, Inspecting Engineer on behalf of the city. The pumps are being erected by the city, by day work, Mr. Jas. A. Crawford, of Duluth, being Supervising Engineer.

Force Main.—The force main is of riveted steel, 42 ins. in diameter, and has a length of about six miles, terminating in a reservoir. Flange steel is specified with a tensile strength of 60,000 lbs., an elongation in 8 ins. of 25%, and a reduction in area of 48%. The chemical requirements are phosphorus and sulphur not to exceed 0.0[illegible] each.

The pipe is made in sections 7 and 8 ft. long, and four of these sections are riveted together in the shops, the joints being telescoped. All rivet holes are sub-punched and reamed, the plates being bolted together in pipe form, and all adjoining sections being bolted together in position before the holes are reamed. The edges of all plates are bevel planed for calking. All shop riveting is done by machine as well as all calking. All riveted joints are proportioned to give as nearly as possible equal strength of plate and rivet. The longitudinal seams are double-riveted lap joints and the circular seams are single-riveted, except for 15 ft. each side of a valve and for 150 ft. from the junction of any two classes of pipe, in the lighter class. Steel rivets are used throughout. The pipe is divided into nine classes; the thickness of the plate used decreasing by 1-32-in. for each class, from ½ to ¼-in. The coating used differs with the contractors on the different sections, one using Trinidad asphalt and dead oil, and the other Los Angeles asphalt and maltha. The friction in the main is calculated by assuming the coefficient for the riveted pipe to be equal to that of a badly tuberculated cast-iron pipe.

As the main follows the lines of streets, it is necessary to have several right-angled curves, and these are all, with one exception, made with a radius of 73.3 ft. The pipe is laid in trenches with an average depth of 8.5 ft. Blow-offs are provided at each low point in the grade line, and air valves at each high point. Manholes are provided about every 600 ft. The details the manhole covers are shown by Fig. 4.

On the line of the main there are six 42-in. gate valves and three check valves. All valves are strengthened to resist temperature strains. The gate valves are manufactured by the Rensselaer Manufacturing Co., of Troy, N. Y., and the check valves by the D. Clint Prescott Co., of Duluth, Minn.

All valves and manholes are placed in brick vaults. Ten-inch branches and valves are provided at frequent intervals along the line of the main, it being the intention to finally lay a 10-in. "rider" of cast-iron pipe, along the entire length of the main. This "rider" is laid from 40th Ave. East to 63d Ave. East; that is, through the former city of Lakeside.

The 42-in. steel pipe was manufactured and laid in two sections of about three miles each. The first one extends from the pump house to Lester River, the contract for furnishing and laying this section, exclusive of trench work, being in the hands of N. P. Hugo, of Duluth, Minn. The con-

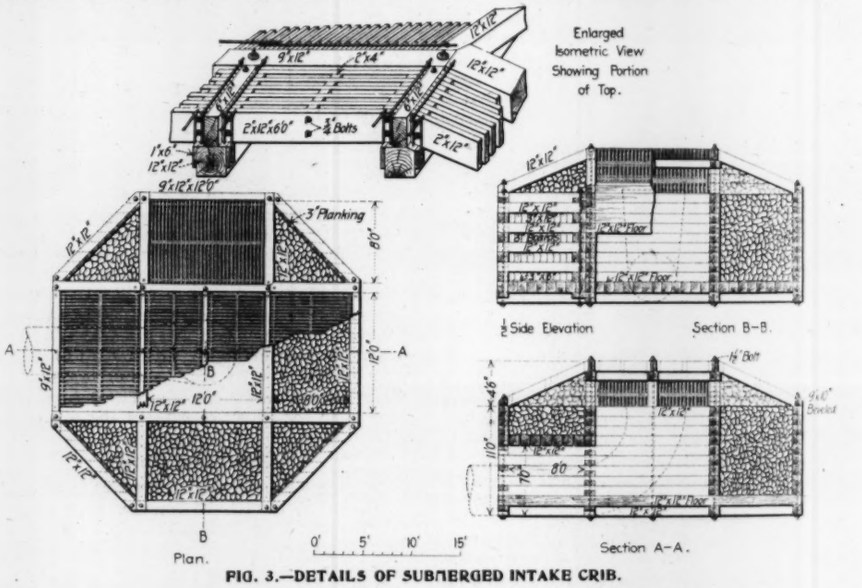


FIG. 3.—DETAILS OF SUBMERGED INTAKE CRIB.

tract price is for class "A" pipe of ½-in. steel, $9 per foot; for class "B," of 15-32 steel, $7.92 per ft., and class "C," of 7-16 steel, $7.614 per ft., the average price per ton being about $63.30, including the laying of the pipe and furnishing all manholes and branches.

The second section from Lester River to the low service reservoir is being constructed by the Carroll-Porter Boiler & Tank Co., of Pittsburg, Pa. The contract price per lineal foot for each of the classes of pipe laid in the trenches, but not including excavating or backfilling, ranges from $4.80 to $6.35, or an average price of about $65 per ton.

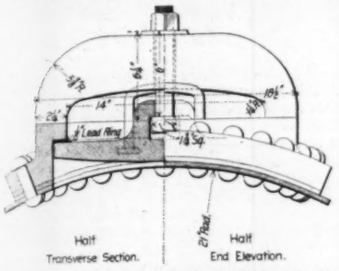


FIG. 4.—DETAILS OF MANHOLE COVERS ON 42-IN. STEEL FORCE MAIN.

Low Level Reservoir.—The low level reservoir is located on Fourth St., between 34th Ave. East and Tischer's Creek. It is planned that this reservoir shall have a capacity of about 30,000,000 gallons in two basins. One basin will be constructed at present. It will be 272½ × 379½ ft., surface measurement, and 25 ft. deep, with a capacity of about 13,500,000 gallons. The elevation of the water surface of the reservoir, when full, will be 290 ft. above the lake. The basin will be constructed partly in fill and partly in cut; the material being a red clay to the full depth of the excavation. In the center of the embankment there will be a puddle wall. The bottom and inside slopes of the basin will be covered with 6 ins. of natural cement concrete, with a surface finish of Portland cement. A heavy block of concrete will be placed entirely around the toe of the inner slope, and also at the toe of the inner slope at the berme. The inner slope from the coping to the berme, half way down the slope, will be faced with cut stone laid in cement. The supply will be taken into the gate house through two 42-in. openings, at different heights, then pass through double copper screens with ¼-in. mesh into the supply main.

Low Level Supply Main.—The low level supply main is projected to run from the reservoir directly down the hill, until it reaches an elevation of about 200 ft. above the lake, and then to run westerly, keeping as near the hydraulic grade line as the arrangement of the streets and the topography of the ground will permit.

The objects sought in keeping this main near the upper line of the low level district are the saving in cost of construction, on account of being able to use much lighter pipe, and the delivery of water to the higher parts of the low level district with as little as possible loss of pressure, due to friction, in the distribution pipes, which carry the water from the supply main to the points to be supplied.

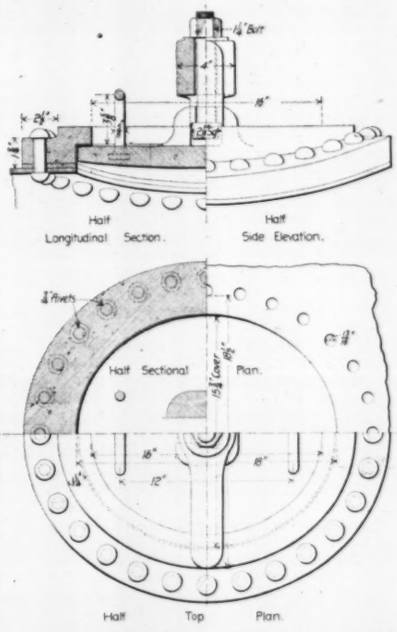
The main supply pipe will be 36 ins. in diameter, so that the friction loss in it will be comparatively light, even with a large consumption, and, as the main is carried further west, it will be reinforced by means of small auxiliary reservoirs, so that nearly the maximum pressure will be maintained immediately back of and above the business streets throughout the entire length of the system.

At present this main is laid as far as 15th Ave. East and Fourth St., where a connection can be made with the pipes of the Duluth Gas & Water Co. system, and thus furnish pure and wholesome water to the city through this plant.

The 36-in. supply main is of cast-iron, with special deep hubs. The cost of the pipe laid was $4.45 per ft., including all items except excavation and back-filling.

This main will be provided with manholes, gate valves, air valves and blow-offs, the same as the force main. All right angle curves are made with a radius of 55 ft. 10 ins. A 6-in. supply rider is planned to be laid alongside of the main with frequent connections with it.

Valves will be placed in the "rider" so that those portions which are at too great an elevation to furnish water from the low level supply main with sufficient pressure at the hydrants for fire service can be supplied from the middle level distribution pipes.



Sub-Mains.—Sub-mains will be connected with the main supply at intervals of about ½-mile, and will be carried down the avenues, for the purpose of supplying the distribution pipes on the streets. These sub-mains will decrease in diameter as they descend the hill, and will, at the foot of the hill, be given outlets into the lake, bay or sewers, so that these mains and the distribution pipes between them may be blown off.

Middle Level District.

The details for the middle level district have not been prepared yet, and this district, as well as the high level district, will be described only in a general way.

Power Plant.—The power house for the middle level district will be situated east of the low level reservoir. It is intended that at first one 3,000,000-gallon vertical compound pump shall be installed. This will be ample for present needs and for some time in the future.

Force Main and Reservoir.—The force main is planned to be a 24-in. pipe, extending directly up the hill from the pump house to the location of the proposed middle service reservoir, which is at Lewis St. and Dunedin Ave., at an elevation of 565 ft. above the lake and about 6,400 ft. from the pump house and almost directly up the hill from it. The reservoir, when built, will be similar in construction to the one in the low level district, having two basins with a total storage of about 10,000,000 gallons. A tank will probably be used temporarily instead of a reservoir.

High Level District.

This district is as yet but sparsely settled. Such developments as have occurred being in settlements on lines of transportation by electric and cable street car lines. It is proposed that when the number of inhabitants in this district justifies the expense, the following plan be carried out:

Power House.—The power house will be situated immediately east of the middle level reservoir. The pumps will raise the water from the middle service to a tower on a hill immediately back of the pump house, the elevation of the top of the tower to be 795 ft. above the lake. From the tower the supply main, 18 ins. in diameter, will run westwardly supplying all points below the 680-ft. contour. The parts of the high level district above the 680-ft. contour will be supplied by secondary pumps, supplying water to tanks conveniently situated. Two of these districts, namely, Woodland Park and Duluth Heights, will need to be supplied at once.

Changes Recommended.

The plans as above described are as they were originally proposed, but a few changes have been made, following the recommendations of L. W. Rundlett, M. Am. Soc. C. E., City Engineer of St. Paul, Minn., who was employed by the city as consulting engineer to examine and report on the plans as prepared.

Mr. Rundlett made an exhaustive report, and recommended the following changes, which are now incorporated in the plans. Owing to the facts that the middle level district was at present but thinly settled, as compared with the low level district, and that the population was mostly in the lower part of the district, he recommended that the middle level reservoir be not built at present, but that a temporary tank be constructed on the reservoir site; that the force main be reduced from 24 to 20 ins. and that instead of immediately building any part of the 24-in. supply main that a 16-in. branch be taken from the middle level force main.

Progress of the Work.

Owing to the uncertainty attending the sale of the city water and light bonds, but little work was done until the fall of 1896, when $1,106,000 worth of bonds were sold.

At present this plant is practically completed, except the reservoir, between the pump house and 15th Ave., E. and 4th St., where a connection is to be made with the system of the Duluth Gas & Water Co., which the city has voted to purchase at the price of $1,250,000.

The estimated cost of the part of the municipal plant, so far constructed, was $750,000, and it will be completed inside of this amount.

In the preparation of the plans, as above outlined, the writer is indebted to the able assistance rendered by the employees of the department and more particularly to E. J. Duffies, Principal Assistant City Engineer.

A TRIPLE-EXPANSION MINE PUMPING ENGINE.

(With full-page plate.)

The accompanying illustrations show a mine pumping engine which the well-known works of Henry R. Worthington has recently contracted to build for the New Jersey Zinc Co. It will be used in the 960-ft. level of the North Hill Mine at Franklin Furnace, N. J. This engine is practically a duplicate of one which was installed about four years ago at the same mine, the only difference being that the present machine has smaller plungers and operates against a higher head. Engines similar to these are now in operation at the Pewabic Mine, Vulcan, Mich.; at the Vulcan shaft of the Penn Iron Mining Company, Vulcan, Mich.; at the Aragon Mine, Norway, Mich.; at a mine of the Copper Queen Consolidated Mining Company in Bisbee, Ariz.; at the Port Henry Iron Company, Port Henry, N. Y., and at a mine near Durango, Mexico, owned by the International Mining Company, of Washington. The duty of these machines varies with the size, the smaller ones showing 75,000,000. At a trial recently made at the Vulcan Mine, the large engine there delivering 1,200 gallons a minute, 1,000 ft. high, showed a duty of over 92,000,000 ft.-lbs. of work for each 1,000 lbs. of steam.

These machines show some novel features in construction. Particular attention is called to the arrangement of piston rods, which enables the high and intermediate steam cylinder heads to be taken off and the pistons taken out without disturbing any other portion of the engine. This patented feature is especially desirable for underground installations, where it is necessary to have each part of the machine as accessible as possible. The steam valves are located below the steam cylinders, requiring no drip cocks, as all cylinders drain into the exhaust pipes. This feature is quite important in mine work, where often the tendency of the station men is to leave the drip cocks open all the time.

The steam valves are of the semi-rotative type,

and in order to facilitate repairs of valves and seats in case any foreign matter finds its way into the steam pipe and cuts the face, the valve seats are formed of cast-iron sleeves which are easily removed, so that they may be taken to the shop to refit, or a new pair made and slipped in. This arrangement requires the engine to be shut down only a few minutes in order to entirely renew the steam valve and seat. The cut-off valves on the high-pressure cylinders are arranged in the same way, and are adjustable independently while the engine is in motion.

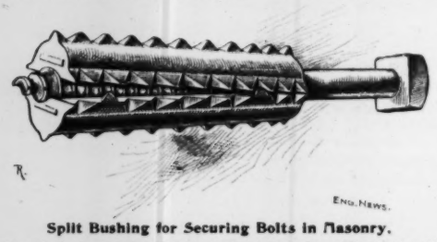
The water ends are of the four-plunger type, with the valve-pots and valve-seats forced in so that no threads come in contact with the water. In designing these pots, care has been taken to make the weights of the pot covers as light as possible so that one man can easily handle them, and no crane or extra help is necessary to get at any of the water valves. The valves themselves are of the standard mine type, of brass, leather faced, and guided by wings.

Any form of condenser may be used. Excellent results have been obtained with an air pump, and a surface condenser located in the suction in such position that all water pumped by the engine will pass through it. In this way a good vacuum is obtained with the least expenditure of power, and all trouble due to a hot sump is avoided. The indicator cards reproduced herewith were taken from an engine in operation at the North Hill Mine, Franklin Furnace, N. J., and show the steam distribution in these machines.

AN ANCHOR-BOLT BUSHING.

The illustration given herewith shows a split bushing recently invented, intended to be used in securing a screw-bolt to stone or brick masonry, or other material in which a thread for the bolt cannot be readily cut. This bushing may be made of lead, iron or other metal, and is divided longitudinally into two parts, with a thread cut on the inside and projecting points cast on the outside.

In using this bushing a hole is first drilled into the masonry slightly larger than the outside diameter of the bushing, which latter is then inserted in the hole. The screw-bolt, which has a diameter somewhat larger than the bore of the bushing, is now screwed in, and if lead is used the screw will cut its own thread and force the bushing firmly against the sides of the hole. If the bushing is made of iron a thread is cast in the bore; and where a particularly strong anchorage is desired,



ENG. NEWS.

Split Bushing for Securing Bolts in Masonry.
The New Jersey Foundry & Machine Co., 26 Cortlandt St. New York, Manufacturers.

or the wall material is soft and liable to crack at the surface, the walls of the bushing are thickened at the inner end. In this case the threaded bolt will force out the inner ends of the bushing and the main grip of the bushing will be at its inner end.

This same bushing may be made with one longitudinal slot and longitudinal V-shaped ribs on the outside. When driven into the wall these ribs cut grooves for themselves which resist the turning of the bushing in screwing in the bolt. The projecting points are intended to perform the same office, as they are really V-shaped ribs cut transversely. This bushing was patented on Jan. 12, 1897, by Mr. John H. Cook, Brooklyn, N. Y. It is being put on the market by the New Jersey Foundry & Machine Co., 26 Cortlandt St., New York city.

THE UNITED STATES AND SPANISH FLEETS.

Our English contemporary, "The Engineer," devotes its leading editorial in its issue of April 22, to a discussion of the relative merits of the two fleets upon whose contests with each other, the attention of naval experts throughout the world is centered. As "The Engineer" is, if not an absolutely impartial critic, at least not prejudiced in favor of the United States, its comments are of much interest. We reprint the editorial practically in full as follows:

The United States ought to be enormously the stronger Power in war. She has battleships which ought to crush anything Spain can oppose to them. She has some cruisers which, taken individually, are, on paper at least, faster if not more powerful than any possessed by Spain. In fighting close to home she could in all probability avail herself of the coast service vessels which would not be able to cross the ocean; and her most powerful sea-going ships are very well suited to their work, for they would not feel the disadvantage of carrying a more limited supply of coal and ammunition than some others do—our English ships for example—because they can easily obtain further supplies when required.

Spain is strong in one particular class of ship, however; that is in armored cruisers. She has, indeed, in the "Almirante Oquendo" class a powerful group of five 20-knot armored cruisers of 7,000 tons displacement; two others—the "Cristobal Colon" and "Emperador Carlos V."—are admirably suited to work with them, having also 20 knots speed; and she has further two unarmored 20-knot cruisers, the "Alfonso XII." and "Lepanto." These all have good armaments of quick-firing guns, and would form a remarkably fast and formidable body of ships, having nearly four knots more speed than the United States battleships, and being much more heavily armored than is usual with cruisers, the "Almirante Oquendo" class having 12-in. belts and 10½ ins. of armor on the principal gun positions, the others being also heavily protected.

In any fighting far away from America the United States fleet might find this an awkward fleet to cope with, in spite of having, as above said, some individual ships which are superior to anything possessed by Spain. The "New York" and the "Brooklyn" are the only armored ships with 20 knots speed, having, in fact, 20.0 and 21.0 knots respectively. The unarmored "Columbia" and "Minneapolis" have still higher speed, namely, 22.8 and 23.0 knots; the "Baltimore" has 20.6; then the "San Francisco" and "New Orleans" have 20.2 and 20.0; and perhaps the "Cincinnati," with 19.0, and others, such as "Marblehead" and "Charleston," with 18.9 and 18.1, might come in; but of these only two are armored, and the United States ships would, if we mistake not, find the error which we have before dwelt on of having 4-in. and 5-in. quick-firing guns, instead of 6-in., tell heavily against them; and on paper, if the fire and protection be taken into account, the Spanish cruising fleet looks much the more powerful.

We have pointed this out because it is interesting to see Spain's strongest element; but we have immediately to add that we hardly see how Spain can avail herself of it if the Americans keep well in hand. At any moment it appears to us that the United States might send out a fleet of battleships and coast service vessels that might move together near Cuba, and, if not blockade it, render it impossible for Spain to communicate efficiently with Cuba, in spite of her splendid swift cruisers, so that the surrender of the island ought to be a mere matter of time and steady fighting with unlimited supplies to draw from. We do not mean that it would be easy work or quickly accomplished. The Spanish army would fight well and hard before giving way, but with unlimited force of men behind them, and a fleet whose superiority would grow almost week by week, surely there can be only one result to be looked for.

Time, indeed, is on the side of the United States in several ways. At present her principal battleships are four, namely, the "Indiana," "Iowa," "Massachusetts" and "Oregon." With these the "New York," "Brooklyn" and "Texas" constitute, as above said, too strong a fleet for even the Spanish armored cruisers to attack, to say nothing of the coast defence ships, such as the "Monterey" and others. The United States further has a number of formidable ships building. Of these the "Kearsarge" and "Kentucky," begun in 1895, ought to be well advanced, and ought to be able to be completed with an effort before very long. The "Alabama," "Illinois" and "Wisconsin" were begun much later, and are probably out of the question.

Under the circumstances, it may well be asked what can Spain hope to do with her swift, powerful cruisers. It has been suggested that New York itself and other towns on the American coast might be threatened or bombarded. We have before now discussed the possibility of bringing such pressure on sea-coast towns, and, so far as town buildings are concerned, the thing appears to us to lie in a nutshell. If the towns are sufficiently ill-advised to pay contributions to escape bombardment, no doubt a fine game may be played as long as it lasts; but probably the government of the country would forbid any such payments being made. The amount of damage that warships could effect on towns is now very moderate. So soon as they had fired a few common shells their power would be exhausted. The amount of ammunition ships carry is very limited, and they dare not fire much of it away for fear of being caught without it and attacked in turn themselves; and a considerable part of their store consists in armor-piercing projectiles, which are unsuited to the work even in the case of shell, and in the case of shot out of the question. In short, it is probable that each round would be worth many times over the damage it could effect, and such work might be likened to a lady throwing jewels at an assailant.

Possibly ill-advised cruisers might try the effect of firing on a town once but not a second time, and a government might well undertake to repay such a town for the damage actually done, so long as it is clearly understood that no contributions is to be paid to the enemy. Merchant shipping lying in a harbor is a different case, it may be freely admitted, but it is not very often that much shipping need be exposed to attack.

Those who have gone into New York harbor must know how extremely difficult and dangerous it would be for cruisers to make their way up into it, and how very easily this might be prevented. Torpedo boats might, indeed, be more likely to attempt to run in at night, but it would be desperate work, and no measure of success in such an attempt would really influence the war, and would furnish a very good ground for a claim for indemnity when the war was ended. On America's trade the Spanish cruisers might no doubt prey, but this is open to the same objection, unless it be held that if once Spain were to lose Cuba the States could not easily press her in other parts of the world. For this there would be much to be said as things stand at the present moment, for, as we have already pointed out, the United States fleet is rather adapted for power in American waters than for expeditions to distant places; but if the struggle is prolonged who can say how Spain will then stand. She has been already bled severely of men for Cuba, and as time goes on her losses must tell heavily. How can a population of 18 millions struggle for any length of time with one of at least 65 millions.

It is notable that in the above discussion, our contemporary makes no mention of the coast defences of the United States; and it may be well to add that should the enemy attempt to attack any of the principal harbors on either coast it would risk the destruction of its vessels either by formidable artillery or by submarine mines. Of course, there are many minor places where few or no defences exist; but to attack and capture such a place, would, as our contemporary remarks, be of absolutely no value to Spain. She might, perhaps, land a force of marines and hold such a place for a short time; and they might effect more or less wanton destruction; but the concentration of troops to meet them could be so rapidly performed that practically the Spanish forces could hold nothing out of range of their vessels' guns.

THE METAL DOME OF THE CITY HALL TOWER IN PHILADELPHIA, PA.

From an illustrated paper lately read before the Engineers' Club, of Philadelphia, by Mr. Francis Schumann, M. Am. Soc. C. E., the following notes are taken relating to the metal dome on the City Hall of Philadelphia:

The tower of the City Hall rises to a total height of 548 ft. 1⅞ ins. above the ground level. The underlying soil is a reddish clay, mixed with sharp pebbles, very stiff and hard to pick and difficult to soften with water. For 337 ft. 4½ ins. this tower is of brick, faced with marble, and forms a hollow shaft averaging 70 ft. square on the outside, and 45 ft. square inside. Upon this masonry shaft rests the metal dome with a height of 210 ft. 9⅝ ins., to the top of the statue of William Penn, surmounting the tower. The estimated weight of the whole tower, measured from the top of the concrete foundation, 15 ft. below the ground line, is 62,768 tons; the 8½-ft. bed of concrete covers an area of 7,150 sq. ft., and weighs about 4,000 tons more. To a height of 90 ft. the masonry is attached to and forms a part of the north wing of the main building.

The structural part of the metal dome is wrought iron, with steel in certain parts of the apex cap; and the general form is one octagonal prism, ending in an octagonal pyramid with rounded outlines. The system of corner posts rest on four box girders placed diagonally across the corners on the top of the masonry, and anchored to the latter by two 3-in. bolts for each girder, passing 70 ft. down into the brickwork. The bracing between the columns consist of horizontal struts, dividing the dome into ten tiers, with each tier panel intersected by tie-rods. The outside, or shell, of this

dome is generally ¼-in. thick, and is made of cast-iron, electroplated; and the actual weight of metal in the dome is as follows:

Total wrought iron and steel	366.8 tons.
" cast iron	570.0 "
" bronze in statues	89.1 "
Grand total	1,025.9 tons.

The statue of William Penn, on top of the tower, is 37 ft. 6⅜ ins. high, and it weighs 53,580 lbs., or 26.79 tons. It is made of bronze and built in sections, united by bolts, to facilitate handling. In addition there are four bronze statues, each 24 ft. high, and four bronze eagles, located around the foot of the rounded, pyramidal dome proper. The thickness of metal in the Penn statue varies from ⅛-in. in the upper parts, to ¾-in. at the ankles, and 1¼ ins. for the soles of the feet. There are no internal braces in any of the statues. The alloy in the statue of Penn and that of the Indian Chief was 90 parts copper to 10 of tin; the proportions in the other statues—the Swedish Man and the Swedish Woman, the Indian Squaw, and in the four eagles—were, 88 parts copper, 10 parts tin and 2 parts zinc. All structural iron was carefully cleaned and painted with iron oxide and linseed oil; one shop coat and two after erection.

The electroplating of the cast-iron shell was conducted in a building especially erected for this purpose. The caustic-soda tanks were made of plate iron, and were 5 × 5 ft., and 31 ft. long. Articles were immersed in this tank for from 2 to 6 hours, in a solution having a temperature of 210° F., to remove all grease, etc. The pickling tanks had the same dimensions, but were made of wood and lead-lined. These contained a 10% solution of sulphuric acid, at a temperature of about 150° F., and in this the pieces were immersed from 2 to 6 hours, to remove rust, silica, etc. The alkali-copper baths had the same dimensions and were also of wood. This bath was maintained at 150°, and here a deposit of copper, or an alloy of copper and tin, was applied. The time of plating was about 24 hours; the current used was from 1,000 to 2,000 amperes, at a pressure of 4 volts. From this tank the article was taken to the acid-copper tank, wood and lead-lined and not heated. Here the time of plating was 72 hours, and the copper deposit amounted to 14 oz. per sq. ft. of surface. The voltage and current were as before. The aluminum plating tank was made of wood and was 5 ft. wide by 8 ft. deep and 31 ft. long. It was heated to 180° by steam coils, and here the anodes were aluminum alloyed with 15% tin, instead of copper. The time of plating was 72 hours, under 4 volts and 2,500 amperes, and the resulting deposit was 2½ oz. per sq. ft. of surface. The last treatment was in a water tank, filled with clean water at 210°.

The original article enters into the technical construction of the dome framing and the stresses involved; and also describes the scaffolding employed in erection.

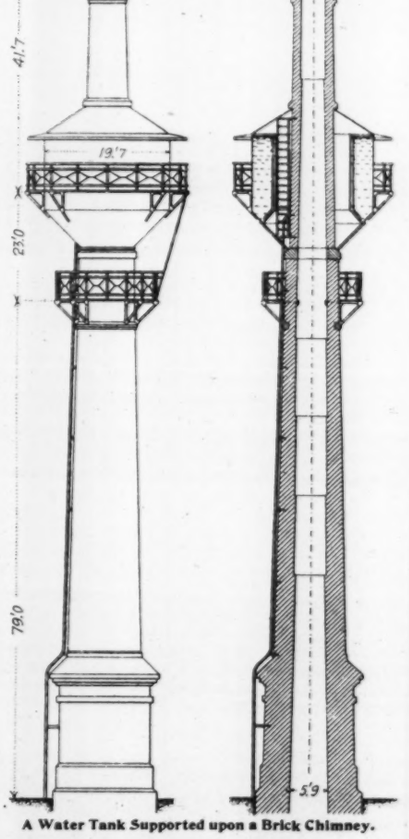
Some interesting observations were made of the movement of the tower during the erection of the dome. To this end a plumb-line of thin piano-wire was suspended from the center of the floor at the top of the masonry, and extended down 230 ft. to the seventh floor of the tower. To the lower end of this line was attached 11½ lbs. of lead immersed in a wooden box filled with molasses and securely fastened to the floor at the center of the tower. This box was 15 ins. square and 18 ins. deep, and the two main axes of the plan were marked on the edges of the box as zero points, with divisions of 1-32-in., extending each way. Observations of movement, direction and force of wind, and temperature, were recorded three times daily, except Sundays, during the erection of the dome.

A table was shown giving the average maximum deviation, temperature and difference in deviation, monthly, for the years 1892-1896, inclusive, in decimals of an inch. As a general result the deviations North and South, in December, January and February, nearly cancelled each other; from March the deviation continued North, increased gradually and reached a maximum in August; when it gradually decreased to November. The deviation East and West was peculiar. It was West in January, February, October, November, December, and in the hottest month, July. The other months showed an easterly deviation. The movement of the tower was due to variations in temperature resulting from the relative position of the sun as affecting the sides of the tower normal to the cardinal points. The deviation was in no case permanent, and the only practical value of the observations was the knowledge that the additional weight of 1,000 tons did not affect the perpendicularity of the tower. Wind storms had no effect whatever; and a slight earthquake shock, of Sept. 1, 1895, was not noticed by the two workmen stationed at the top of the masonry.

The entire settlement of the tower, from first to last, was as follows: The upper part of the masonry tower, about 80 ft. above the ground level, settled a little over 4 ins. from the compression of the mortar in the brick joints; as this mortar had not hardened in proportion to the rapid increment of dead weight. The foundation only settled about 1¾ ins., and all the settlement did not throw the tower out of plumb.

A COMBINED CHIMNEY AND ELEVATED WATER TANK.

In a paper upon "Modern Chimney Constructions," by Alphonse Custodis, published in "Der Praktische Maschinen Constructeur," reference is made to the manner in which a factory chimney



A Water Tank Supported upon a Brick Chimney.

may be utilized to support a water tank. An elevation and a section of the design there shown is reproduced herewith. This tank construction has been patented by Prof. O. Intze and F. A. Neumann, of Aachen, Germany. It is stated that several such elevated tanks have been built with a capacity of 26,400 gallons or less.

DANGER FROM THE USE OF ELECTRICITY IN COAL MINES.

In the Consolidation Colliery, near Gelsen-Kirchen, Westphalia, a series of interesting tests have been made of the dangers attending the use of the electrical apparatus actually employed in coal mines. These tests, says London "Engineering," have been broader and more complete than any other investigations of the kind in Belgium, France or Germany.

The tests were made in September, October and November of 1897, by Heise, on behalf of the Westphalian miners, and by Thiem, on behalf of Siemens & Halske, of Berlin, who furnished the apparatus. The special testing gallery was 110 ft. long, 6 ft. high and 4½ ft. wide; it was open at one end and closed at the other, and lined with three layers of pitch-pine held by I-irons. Along the top ran a line of safety holes, covered with stout paper, and in one side were 15 windows of strong glass. At the end of the passage was the explosive chamber, of 350 cu. ft. capacity, and fitted with three safety holes and four windows. The methane gas came from an abandoned working fitted with a ventilating pipe to relieve the pressure; and a branch of this pipe introduced into the chamber gas containing an average of 38% of methane. A gas-meter was inserted in the pipe and the flow was regulated so as to obtain, as a rule, a 6% mixture; though a percentage as high as 9.5 was tried. The latter mixture was highly explosive; the former slightly so.

The incandescent lamp tests were the most complete. Lamps, with their bulbs, were fixed on iron rods and broken. In the 200 experiments, bulb and filaments broke simultaneously, and there was bad sparking, and sometimes explosion and sometimes not. In other cases the filaments remained whole, and again explosion did or did not follow. Currents of less than 0.6 ampere, continuous or alternating, did not produce ignition, though there was often sparking; stronger currents generally caused explosion.

The conclusions as to lamps were: Use stout globes around the bulbs, to prevent cracking by water dripping on the hot bulb; and for further protection use cages. Take low-current lamps (0.6 ampere maximum) and high voltage, but not above 150 volts; all excessive voltages are dangerous. Have short leading-in wires far apart, lest they bend together and cause short circuits. For the same reason, avoid lamps with two filaments in series. This summing up is against the common portable lamp, which has the further disadvantage of not indicating the presence of firedamp. Aside from this, incandescent electric lights are recommended as being probably the safest means of lighting a mine. Arc lamps do not appear to ignite coal dust, even in an atmosphere of 4% methane; but in 6% explosions took place, whether the lamp was already burning, or was switched in. A dust storm did not make the arc flare up. Both continuous and alternating arc lamps are condemned for fiery mines; though they have been safely used in rubber works in air saturated with benzine vapors. While slow switching is generally more dangerous on account of arcs forming, a rapid motion of the switch is also to be avoided. Spark extinguishers, which form a momentary arc, are condemned. Hot wire resistance seems in itself harmless, but danger threatens from contacts. Explosion followed where in a set of resistances, placed horizontally, one hot spiral touched another. Melting wires, and especially copper, may ignite the gas; but an iron wire, buried in coal dust and heated by the current until it arced strongly, would not ignite the dust, either in the pile or in a cloud.

Of electric motors, larger sizes were safer than small ones, because they are less affected by variations in load. Carbon brushes spark so little that they are least liable to do harm. A motor under a fine gauze cover set fire to the explosive mixture in the box when started, but the flame did not strike through the gauze. Experiments with 5-HP. tri-phase motors were quite satisfactory; a brush was lifted 30 times from one of the contact rings without any harmful results. To avoid danger, from very abrupt changes in load, the motors should be encased, and double brushes used.

The general summary of the tests, as published in the "Elektrotechnische Zeitschrift" for January, 1898, is not unfavorable to electrical apparatus. But ordinary precautions must be applied and extra care will be profitable. Continuous current electric motors and switches, fuses, etc., should be avoided in dangerous parts, and they should be encased wherever used.

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The Naval Appropriation Bill as agreed on by a conference committee, provides for 3 naval battleships of 11,000 tons each, to cost $3,000,000 each, exclusive of armor and armament, 4 coast-defense monitors to cost $1,250,000 each, 12 torpedo-boats and 16 torpedo-boat destroyers at a total cost of $6,900,000, and a gunboat for the Great Lakes, estimated to cost $260,000. The torpedo-boats and torpedo-boat destroyers are directly in line with the policy advocated in these columns last week, of strengthening the weakest places in the present navy. At present we have 8 torpedo-boats in service and 14 more building, most of which will soon be ready to commission. The vessels provided for in the present naval appropriation bill, therefore, will give the Navy a total fleet of 34 torpedo-boats, which is certainly none too large, considering the extent of our coasts. It is not so clear, however, that the $9,000,000 for battleships represents the best use that could be made of the money. When the vessels now building are completed, the Navy will have nine first-class battleships, but only two armored cruisers, the "Brooklyn" and the "New York." It is true we have a good list of so-called "protected cruisers," which have protective decks, varying from 1½ ins. in the "Boston" to 4¾ ins. in the "Olympia." But it remains to be seen how many of these vessels will stand the impact of shot and shell.

About the best thing that can be said for the three additional battleships, it appears to us, is that they indicate a defensive rather than an aggressive national policy, which we certainly hold to be the proper one for this country, as a rule. At the same time, it is to be remembered that in war it is sometimes necessary to "conquer a peace," and it is not quite clear what our big battleships could do in an aggressive way, except, of course, in a battle between naval fleets or against vessels of their own class. They are too slow of speed to capture any modern cruisers, and they offer a shining mark for torpedo-boats. As for attacking a hostile port, it is difficult to see how even a battleship's weapons would be of much effect against modern disappearing guns and mortars, which are mounted in pits, where only a plunging shot can reach them. Further, the perfection of light explosives and submarine mines of various classes has so greatly increased the means of harbor defense, that it would probably be mere foolhardiness for a war vessel to enter a hostile port where the enemy had provided a modern system of explosive mines.

The real usefulness of the battleship is unquestionably for fleet action. A fleet made up of cruisers, gunboats and minor vessels, which should meet a hostile fleet containing one or more battleships, would have to run away or risk almost certain defeat; but when we have provided battleships enough to give fighting strength to as many fleets as we are likely to assemble at one time, it is not easy to see what use we have for more.

For the work of driving an enemy's roving cruisers from the seas, a vessel which unites high speed, heavy armament and armor enough to give her a fair chance in fighting any vessel of the cruiser class, seems to us a far more useful vessel than the battleship.

The provision for five new dry-docks in the bill is one that is to be heartily commended, and under the present efficient head of the Bureau of Yards and Docks, the nation may feel confident that these new structures will fulfil the purpose for which they are designed. One of the new docks is to be of steel, the others of "timber or granite," according to present reports, but a proper use of concrete will doubtless be permissible.

In commenting on the New York Canal work in our issue of Jan. 13, we strongly urged that work should be immediately stopped on all contracts until it was known what the State would do with reference to furnishing funds to complete the work on the lines originally laid down. This course was originally proposed by Hon. Jas. A. Roberts, the Comptroller of the State, at a time when the State had still in its treasury over $3,000,000 of the original $9,000,000 appropriation for canal improvement. Had this course been adopted, the plans for work might have been modified so that the expenditure of this sum would give the greatest immediate benefit and would have placed the canals in at least decent shape for navigation.

Unfortunately, as it appears to us, the other members of the Canal Board held that the contracts already let must be proceeded with exactly as if funds were available to complete the entire work, and the contractors were ordered to go ahead.

On April 26, however, notice was issued to all contractors to stop all new work at once no matter in what condition it might be, as the $9,000,000 appropriation had been exhausted. On May 1 contractors will have earned $8,802,634, and contracts for the remaining $200,000 are all out.

If the contractors can be ordered to stop work at this time, no matter in what condition their section may be, it is difficult to see why their work might not have been stopped four months earlier. The funds at that time available could have been apportioned to the parts of the work which would most directly benefit navigation, and which would still be of permanent value to the canals. But to spend all the money available in undertaking work which may not be completed for four years hence, and will be of little benefit to navigation until it is completed, would appear to be a very poor policy.

Between the war situation, which affects the market for securities, and the ruling of the Comptroller of New York that the city has far exceeded its constitutional debt limit, the New York Rapid Transit enterprise is evidently shelved for a good while to come. As our readers are aware, we have steadily favored this project through all its years of vicissitudes; but while the people undoubtedly desire it to be carried out as a municipal enterprise, the leaders of both political parties are opposed to it, and have been thus far successful in preventing its success.

The various schemes for improving the transit facilities in New York by extensions of the Manhattan Elevated and by further avenues over or under the East River are also likely to be dropped until the security market is more favorable. The introduction of the electric conduit system on Manhattan Island, however, and of the through lines of surface cars across the Brooklyn Bridge have done very much to improve the city's transit facilities, and while the need for more lines still exists, the city can wait for them much better now than a year ago.

A writer in a New York journal calls attention to the complexity of modern war-ship construction; compares the battleship to a huge steel honeycomb, with a multitude of compartments, which have to be protected by water-tight doors, and are jammed full of all manner of complicated machinery, for running the ship, hoisting ammunition, training guns, lighting and ventilating the ship, and doing the thousand and one things by mechanical means that were once performed by human labor. He points out the great liability to disarrangement, under these conditions, and leaves the general impression that the final behavior of our ships in action against a Spanish force is still an unsolved problem. But, in admitting that what he says is largely true, he omits mention of one important and, in fact, controlling factor, and that is the quality of the human agency on board the American war vessel, which cares for and handles all this machinery, and controls its operation before action and in action.

In other words, the more complex the fighting mechanism, the greater advantage the American sailor should have, as compared with the Spaniard. It is true that many of Spain's ships have been constructed by one of the best builders of war-ships in the world, and the equipment and armament are all designed upon the latest modern lines. But the English builders hand these ships over the Spaniards to care for—and to fight. And herein comes the difference. The Spanish people have little or no mechanical skill, or experience; they have never given to the world a single invention worthy of note; and they cannot even build or repair their own ships, or provide war material, except through the aid of imported machinery and labor. In their hands alone, all this complication of modern war material is liable to rapid deterioration, through sheer ignorance and neglect; and in the heat of battle Spanish officers and men will be very likely to make blunders that may be fatal. Personally, the Biscayan sailor is doubtless brave, but he is some centuries behind the times; and if he were beaten in the wooden monsters of Nelson's time, he will be very apt to fail when handicapped by the necessary handling of innumerable mechanical appliances which he does not, and cannot understand, as a Yankee machinist or sailor would understand them. The latter has back of him all the traditions of a nation famed for its mechanical skill and inventive genius; and in a modern sea battle, it is the men behind the guns, in the bowels of the ship, and especially in the conning tower, that will decide the result.

There is another element still that will have a marked influence, we predict, upon the ultimate outcome of this war; and it has only an indirect bearing upon the bravery of man, or the mechanical ability to handle a warship. It is a notorious fact that corruption is rampant in all branches of Spanish official life, and especially in the army and navy. A member of the editorial staff of this journal, while traveling in Spain two years ago, had an opportunity of witnessing the eagerness of all classes for "tips." On one occasion a judge in charge of a court of considerable importance in Madrid offered to perform for him for the trifling sum of two pesetas, or forty cents, an act distinctly forbidden by the official regulations.

The stealings of Weyler and his associates in Cuba, from the Spanish soldier as well as the Cuban refugees, are too well-known to need comment; and the insurrections in Cuba and the Philippine Islands to-day, and those previous uprisings that have, within the century, driven the flag of Spain from almost half the world, all had their incentive in the robbery and corruption practiced by Spanish officials. When corruption rules in the affairs of a nation, its influence will extend to every department of the state and to every army corps or naval vessel. It means lax discipline among officers and men; the failure to provide necessary materials of requisite quality for waging warfare; and in the case of modern

warships, that inattention to details which must inevitably result in the deterioration of their fighting qualities. This belief is borne out in the case of some of Spain's new torpedo boat destroyers, which gave a trial speed of 28 or more knots, and, in Spanish hands, a few months later, could hardly make 10 knots. These latter vessels are especially delicate pieces of machinery. Everything is sacrificed to engine and boiler capacity and speed; and it is in these boats especially that we may expect Spanish inefficiency to first make itself evident. With all due credit awarded to the quality of some of the ships of the Spanish navy, to the personal bravery of the officers and men upon them, and to the patriotism of the Spanish people, there is strong reason to believe that the complexity of modern naval fighting machinery will tell far more to the disadvantage of Spain than of the United States.

A NEW STANDARD NEEDED FOR M. C. B. COUPLERS.

The multiplicity of car couplers of the M. C. B. standard type, which are now on the market, is proving a serious matter to the railway companies. It may be of interest to review the history of the M. C. B. standard coupler and see how the present situation came about.

In the years from 1870 to 1888 a legion of devices were invented for automatically coupling railway freight cars, and many fortunes were spent in attempts to secure their introduction. It was evident to all railway men, however, that no matter how good a device might be mechanically, it was useless for any railway to adopt it unless all other railways would do the same.

The only official organization of railway companies competent to select and decide upon a standard form of coupler was the Master Car Builders' Association; and the difficulties which that body experienced in its attempts to select and adopt a standard coupler were very great. The first step was taken in 1884, when a motion of the late E. B. Wall to the effect that the Association should go on record as endorsing the "vertical plane" principle as the correct one for an automatic coupler was adopted after a long and heated debate. It was not till 1887, however, that action was finally taken by the Association adopting the Janney type of coupler as the standard of the Association. In making this adoption as few parts were made standard as possible, and the largest liberty was left to the manufacturers of couplers to vary their design in such details as the operating gear, the form of lock, and other features. In fact the only aim was to make sure that the coupling on one car would fit the coupling on any other, and that the outer dimensions of the drawbar should be such as would make it possible to substitute one style of drawbar for another, with little, if any, change in the draft timbers beneath the car floor. This was manifestly the only proper course; for if any part of the coupler had been fixed irrevocably, the door would have been shut to any changes or improvements which experience with the coupler in service on a large scale might show to be necessary. Besides this, the interests engaged in pushing the different car couplers for adoption were so numerous and powerful, that it was necessary to make a standard which should include as many as possible in order to secure its adoption at all.

But necessary as it doubtless was a decade ago to leave as wide a door as possible open for improvements in the M. C. B. coupler, its results have been in some respects annoying and expensive to the railways. At present the part of the coupler which most frequently suffers breakage is the knuckle, and in order to replace a broken knuckle with one of the same kind, railways are obliged to carry a great variety of M. C. B. knuckles at every repair point. At a recent meeting of the Western Railway Club one member remarked in the course of the discussion of a paper on tests of M. C. B. couplers (Eng. News, April 14, p. 238):

> There is a greater question facing the railroad companies at the present time than the matter of tests of couplers, and that is the great variety of couplers in existence. We have about 60 different kinds of knuckles in use. Every inventor, from the north end to the south of the United States and from the east end to the west, has got a knuckle of his own design. The Master Car Builders' Association must soon face the question of adopting a standard knuckle or knuckles. We have got to rule out a great many knuckles.

Mr. F. W. Brazier, Assistant Superintendent of Machinery of the Illinois Central R. R., said:

> It has been the bane of my life to have so many different kinds of knuckles and couplers. Our shops are filled with couplers which have been taken off of cars, and for the replacement of which we could get none of similar make. I think that we are rapidly approaching the time when we must adopt some standard, and I certainly hope the day is not far distant. I do not want to express an opinion as to which coupler is the best, but if we could reduce the number to half a dozen I should very much like to see it done.

It was not uncommon some years ago, when M. C. B. couplers were far fewer in number than today, to hear the sentiment expressed that the M. C. B. Association ought to have adopted standards for every detail of the coupler when it took action in 1887; and this sentiment is much stronger today. Nevertheless, for the reasons stated above, it is probable that the course the Association took in 1887 in leaving the door as widely open as possible to improvements was a wise one.

In order to see what course the railways ought to take to meet the evils arising from the multiplicity of M. C. B. couplers on the market and in use, it will be well to look forward a little. By the terms of the extension of time granted last December by the Interstate Commerce Commission, the railways have until Jan. 1, 1900, to complete the equipment of their cars with automatic couplers. Thus we can fairly expect that in 20 months from the present time all freight cars interchanged between different railways will be equipped with the M. C. B. couplers. But it must be remembered that the present M. C. B. standard coupler is designed to do two things, couple with itself, and couple with the old-style drawhead with a link-and-pin. To permit the entrance of the link the knuckle has a slot opening about 5 ins. in height, and the lugs above and below this slot have a hole to receive the pin. But when all cars have M. C. B. couplers, it will no longer be necessary to have this slot and hole in the knuckle. A solid knuckle can be substituted which will be vastly stronger, cheaper to make, and which will wear for a very much longer time. In addition, the lugs of the coupler head which engage the knuckle can well be increased in depth. In short, the M. C. B. coupler will need to be redesigned to meet the conditions which will exist on all railways a year and a-half from now.

Of course, the coupler equipment in use will be continued in service; but for the renewal of broken couplers and the equipment of new cars, a coupler ought to be designed that will meet the changed conditions when a compromise coupling is no longer essential. It is not too soon for the Master Car Builders' Association to take this matter up. The manifest advantages of solid knuckles are sure to cause them to be placed on the market by coupler manufacturers as soon as the link-and-pin drawbar disappears; and the Association ought to take the lead in this matter before further varieties in the M. C. B. coupler are put forth.

Further than this, when the Association undertakes the task of revising the present standard, on the lines above indicated, it is worth considering, at least, whether it should not go further and lay down a definite standard for each and every part of the coupler and its attachments. It was not possible, and it would have been unwise to have attempted this ten years ago; but the conditions to-day are changed. The experience with the M. C. B. coupler has now been so extensive that it is a far easier task to fix upon standards for every detail of the coupler than it was to settle upon the contour lines alone ten years ago. The patents which then stood in the way of the adoption of standards have mostly expired. The need of absolute uniformity is now understood by all, and a large majority of the railways of the country will doubtless be found emphatic in its favor.

That it is the urgent duty of the M. C. B. Association to appoint a committee at its next meeting to recommend changes in the knuckle and drawbar head, and to consider the complete standardization of the coupler, seems evident in the light of the preceding discussion. Such a committee would not render its report before the convention of June, 1899, and should its recommendations go at once to letter ballot, the standard could not be ready much before the time when the compulsory withdrawal of the link-and-pin couplers will create a demand for it.

It is true that with the disappearance of the link-and-pin drawheads, a chief source of breakage of the present knuckles and couplers will disappear. On the other hand, the shocks to which couplers are subjected are likely to be increased in the future with the steady increase in length of trains, power of locomotives, weights of cars, and especially with the introduction of steel cars, the steel sills of which will absorb less of the shocks of buffing and jerking than the present wooden sills. For these reasons, as well as for the reasons already pointed out, the solid knuckle for M. C. B. couplers seems to be a future necessity.

THE CONTRARINESS OF CAST IRON.

Recent technical literature on the subject of cast iron is most voluminous, and its bulk is rapidly increasing. For some years past the American Institute of Mining Engineers and the American Society of Mechanical Engineers, to say nothing of a host of local engineering societies, have been regaled with papers and discussions upon the subject, and now we have journals devoted to the interests of the foundry and several foundrymen's associations, all devoted to the study of cast iron, its "pure cussedness" and its "total depravity." Mr. W. J. Keep and Mr. Thos. D. West have enlightened us on the merits and demerits of different shapes of test bars, and they and other writers have written many lengthy papers on silicon, carbon, shrinkage and chill. Major McDowell has recently beaten the record on tests of cast iron, having cast a sample with 49,000 lbs. tensile strength per square inch. The New York City Building Department has shown us how cast iron columns supposed to have a factor of safety of 5 have an actual factor under steady central load of only 2.2, and no one knows how much less under eccentric loads or shocks. Many books and parts of books have been written about cast iron, and no doubt a book containing what we don't know about it would be larger than any of them.

But while the writers keep a-writing and the testing experts keep a-testing the world goes on using cast iron in sections proportioned either by rule-of-thumb, or by what is far worse, Gordon's formula, and the cast iron keeps following its normal law, which is, "it is the unexpected that happens." In the form of railway car wheels it runs hundreds of thousands of miles and stands millions of shocks without breaking, and in the form of columns it breaks down before the building in which it is placed is completed.

We are led to make these cursory remarks upon reading the latest contribution to the vast literature of this most complex subject, a paper by Mr. P. Kreuzpointner, of the Pennsylvania Railroad Testing Department, at Altoona, read before the Pittsburg Foundrymen's Association on April 25, entitled "Difficulties Encountered in Testing Cast Iron." He tells us, in discussing the causes of the erratic behavior of cast iron, that it closely resembles rock in its structure, and that "this structure is subject to the same conditions and influences, both in rock and cast iron." He also likens the cooling of liquid cast iron, with the accompanying segregation of its elements, to the freezing of a solution of salt and water, with its segregation of ice from a solution containing below 76.3 parts salt to 100 parts water, and of salt when the solution contains a higher proportion of salt. We quote below an extract from his paper, giving the results obtained in testing different samples of the same mixture:

> The other day I made some tests of cast iron with the following results: The shrinkage ran all the way from 0.08 to 0.13 in. per foot, while the transverse strength varied from 14,000 to 22,000 lbs. The test pieces were 2 ins. square; supports were 12 ins. apart. Some of the results varied from 14,000 to 19,000 lbs., while the shrinkage remained uniformly at 0.08 in. There were tests with a strength of 14,000 lbs. and a shrinkage of 0.10 in. and two tests with a strength of 20,000 lbs. and also a shrinkage of 0.10-in. There was a test with a strength of 18,200 lbs., 0.16 in. shrinkage and 1-16 in. chill; while the next test gave also 18,200 strength, but a shrinkage of 0.11 in. and ¼ in. chill. All these tests were from the same mixture, cast under the same conditions and the manner of testing was identical in every case.

Mr. Kreuzpointner follows the statement of the results of these tests with a long explanation of the multifariousness of cast iron, from which we quote some extracts below. We commend them to the attention of those who have been led by the writings of others to consider that the variations in strength, chill, shrinkage, etc., are all due simply to the content of silicon. They certainly open up the subject for further discussion, and give an opportunity, if any is needed, for the other writers to still further increase the bulk of cast iron literature.

We can readily imagine the almost incomprehensible complexity of conditions arising in a cooling mass of cast iron, which, of all classes of cast metals, is composed of a maximum of elements besides iron and carbon, by the partial or complete absorption, saturation, equalization, segregation, exchange and interchange of the various elements, according to their affinity, the law of crystallization, degree of heat, of melting and rate of cooling. Thus we can imagine an excess of sulphur being segregated out at the point of saturation with sulphur of the other elements, provided there be sufficient heat and time in cooling to favor complete saturation of one element with another element, most congenial to its nature. Supposing that ideal state has not been reached, then we have a disproportion of elements, a want of equilibrium, as it were, whereby the physical qualities of the metal are influenced in a manner unknown and puzzling and not seldom very perplexing to both the foundrymen and the engineer. And what happens with one element like sulphur will of course happen with any one of the other elements, or two or three of them at a time, according, not only to the percentage present of these elements, but also to the readiness of each one individually and all of them collectively, to absorb, to become saturated with one or all of the elements each or all can absorb, thus forming a chemical composition in complete equilibrium of elements, as distinct from a state where the elements are unbalanced chemically or form merely partial mechanical mixtures. In these reciprocal effects of absorption and segregation, of solution and saturation of the varying and ever variable elements composing cast iron and steel complicated still more by the melting point and rate of cooling, we find the reasons and causes for the difficulties we encounter in testing cast iron and steel for their physical qualities, but more so in cast iron, because of the greater percentages and number of elements present and the variation of percentages of these elements.

In designing, therefore, or specifying test bars for standard use, these facts have to be taken into consideration in order to avoid dissatisfaction, distrust, confusion and misunderstanding. All the more so since, even with an ideal mixture, never attainable in everyday practice, the rate of cooling influences the physical qualities of cast iron in different portions of a casting differently, the portions cooling quickly being of finer grain, giving higher tensile strength than the portions cooling more slowly, and therefore having a larger grain, or crystals, if you please.

If we go down in the scale of temperature from the highest degree of fluidity to the point of complete solidification, we have a series of formation of groups of elements, the last of which is decisive of the quality of the metal. Conversely, when heat is applied to the iron the various groups will not melt simultaneously, unless all the elements are proportional to each other, as in a solution of salt water, but will melt at various degrees of heat until at a sufficiently high degree of heat all the elements unite into one homogenoous mass, to separate again on cooling.

Thus far we have considered the question of solution and segregation as a whole, affecting the physical qualities of cast iron. However, we become still more impressed with the reasons why we encounter difficulties in testing cast iron, if we examine into the details of the formation of crystals. Crystals are formed in a solution by the aggregation of certain elements forming eventually a body of angular form. This form is seldom symmetrical in the individual crystals of a mass of metal, apparently because of the crowding of each other while forming, and probably also because of the insufficient time in many instances given for their formation. * * * *

The difficulties of determining the useful or commercial qualities of a metal by physical test (and incidentally also by chemical analysis), increase with the proportional increase of the chemical elements. And these difficulties are greatest in cast iron because of the heterogeneous composition of its elements, which is apt to cause a variation in structure in a piece of cast iron and, as a consequence, a variation in quality in different parts. To represent this difference approximately is the difficulty when we attempt to devise means and methods of testing cast iron. How to overcome these difficulties and use a satisfactory and economical method of testing is not within the scope of this paper to discuss. The author's object was only to call attention to the presence of these difficulties, because, as said in the beginning, we can defend ourselves more intelligently if we know the nature and source of the danger we are going to encounter. Whatever these difficulties may be, they should not be considered an obstacle to so intelligent and energetic a body of men as American foundrymen in general, and the Pittsburg foundrymen in particular, but rather an incentive to study the complex phenomena of physical metallurgy carefully, patiently and diligently.

LETTERS TO THE EDITOR.

Formulas for the Flow of Water in Open Channels of Trapezoidal Section.

Sir: In Professor Merriman's valuable text-book "Treatise on Hydraulics," under Article 98, pages 227, 228, and 229, we find given the proper dimensions for the "trapezoidal section," when it is designed to discharge (q) cubic feet per second, where

$q = c\,a\sqrt{r\,s}$,

r = hydraulic radius,
a = area of water cross-section,
p = wetted perimeter,
b = bottom width,
d = depth of fluid,
Θ = the angle made by the side slopes with the horizontal.

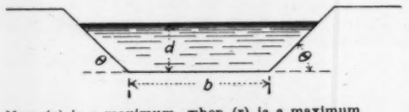
Then

$$a = d\,(b + d\,\cot\,\Theta);$$

$$p = b + \frac{2\,d}{\text{Sin}\,\Theta};$$

and

$$r = \frac{a}{p}.$$



Now (q) is a maximum, when (r) is a maximum.

The formula deduced to meet these conditions is as follows:

$$b = d\left\{\frac{2}{\text{Sin}\,\Theta} - 2\,\cot\,\Theta\right\}.$$

This formula can be much simplified as follows:

$$b = d\left\{\frac{2}{\text{Sin}\,\Theta} - \frac{2\cos\,\Theta}{\text{Sin}\,\Theta}\right\};$$

$$b = d\left\{\frac{2\,(1-\cos\,\Theta)}{\text{Sin}\,\Theta}\right\};$$

$$b = d\,(2\,\tan\,\tfrac{1}{2}\,\Theta);$$

$$b = 2\,d\,\tan\,\tfrac{1}{2}\,\Theta,$$

which is the relation which gives the most advantageous cross-section. If $\Theta = 90°$, we have b = 2 d, which has previously been shown to be the best proportion to use in rectangular sections for minimum friction and maximum hydraulic radius. Yours truly,

J. Calvin Locke.

177 Columbia Heights, Brooklyn, N. Y., April 27, 1898.

(We have submitted the above letter to Prof. Merriman, who writes that Mr. Locke's simplification of the formula is correct and will be adopted in the next edition of "Hydraulics".—Ed.)

The Computation of Strains in Coal and Grain Bins.

Sir: In the issue of Engineering News of April 7, 1898, Mr. J. J. Israels says:

Mr. Cain asserts that it is necessary to take into account the wall friction in the computation of strains in coal bins. This assertion is erroneous, as I shall prove later on.

The expected proof has not been forthcoming.

In discussing a purely scientific question, the usual method is first to prove and then state the conclusion. As Mr. Israels has not followed this time honored custom, it is really not necessary for me to answer a mere statement without proof, but there are doubtless some of your readers who desire more light on the subject of wall friction for any kind of a retaining wall or board, coal or wheat bin, and I shall group together here some established facts which prove, beyond any sort of doubt, that a part of the weight of any granular mass confined on one or more sides by walls, bins, etc., is held up by the friction exerted between the wall or bin and the retained mass.

A brief statement of a few results of experiments made by various authors will now be given, leaving the interested reader to look up the details in the original publications:

(1) In Engineering News for May 15, 1886, a resumé of various experiments, made from 1829 to 1836, is given. In one of the experiments, damp quartz sand of medium size filled a box 2.3 ft. long × 2.0 ft. broad × 2.3 ft. deep, the box having a detachable bottom, no top and vertical sides. The weight of sand transmitted to the bottom was ascertained by actual weighing, at the moment the bottom was about to be detached, to be 55% of the total weight of sand in the box. The four vertical sides thus held up 45% of the weight of sand. The weight of sand in the box was 468 kilos., and when a weight of 258 kilos. was placed on top of the sand, the sides again, by the friction exerted, held up 45% of the total load (726 kilos.) as the bottom was about to fall. With a surcharge of 508 kilos., the total wall friction was found to amount to 49% of the total load (1,016 kilos.).

(2) Mr. Pence, in Engineering News for [illegible] 27, 1898, quotes some English experiments on stored grain in small bins, 7 to 21 ins. in diameter, with square or hexagonal cross-sections, the conclusion being reached that "the maximum pressure that can come upon the bottom of a bin of wheat is equal (nearly) to the weight of a prism of wheat with a base equal to the bottom of the bin and altitude equal to the diameter of the inscribed circle." Mr. Max Toltz (Eng. News, April 7, 1898) shows that recent experiments by Mr. Prante indicate that the lateral pressures are greatly increased, when the grain is running out at the bottom, so that it would be very unwise to use the simple rule above in designing a bin. It suffices to show, however, what is contended—that a part of the weight of stored grain is held up by the vertical sides of the bin.

(3) Mr. Siegler ("Annales des Ponts et Chaussées," April, 1897) experimented on a box 1 ft. square at the base and filled successively with sand to heights of ½, ¾ and 1 ft., respectively. One of the vertical sides of the box was movable and the vertical components of the earth thrust on it were found, by measuring the increased friction at the base on blocks moved under the board, to be 0.66 lbs., 1.76 lbs. and 3.97 lbs., respectively. Similarly, for a box of 0.5 × 0.8 ft. cross-section, filled with sand to heights of 0.6 ft. and 1.18 ft., the relative weights of sand sustained by the bottom and sides was as 1 to 1 and 1 to 2, respectively. In this case, a movable bottom was supported on iron blocks and the forces necessary to move the blocks under the sides and bottom were measured, and it is said that the total weights ascertained by the friction apparatus checked out with the actual to within 5%.

(4) An account of the most extensive series of experiments on earth thrust yet published is given by Leygue, in "Annales des Ponts et Chaussees" for November, 1885. It takes up altogether 216 pages. In a preliminary chapter in connection with ascertaining the coefficient of adhesion, M. Leygue found by actual weighing the wall friction exerted on the vertical sides of a box having a base 4 × 4 ins. For heights of sand of 1.2, 2.4 and 3.5 ins., the four vertical sides held up 21%, 25% and 35%, respectively, of the total weight of sand in the box. The angle of repose of the sand was about 35°.

All of the above experiments agree in showing the existence of wall friction, whether for retaining walls or grain bins. Its amount for any special case cannot well be deduced from them.

(5) Leygue, however, in endeavoring to measure earth thrust by the compression of springs placed in front of a board retaining sand, found that the board was forced to the floor by the vertical component of the earth thrust and that, indeed, for various inclinations of the board and of the sand surface to the horizontal, forces had to be exerted upwards in the plane of the board (by means of ropes), about equal to the experimentally determined component of the earth thrust normal to the board multiplied by the coefficient of friction of board on sand, in order to keep the board clear of the floor as it moved forward from the earth thrust.

Here is a quantitative experimental determination of the very point at issue. A retaining wall or side of a coal or grain bin is exactly in the condition of the board above when the upward forces are omitted; for the earth, coal or grain settles appreciably relative to the wall or bin, and as it moves downwards, however slightly, the full wall friction is exerted. If we call N the actual component of the thrust normal to the wall and f the coefficient of friction between earth, coal or grain and wall, then N f is the total wall friction exerted downward along the back of the wall. This component when combined with N gives a total resultant of the earth, coal or grain thrust, which is plainly directed below the normal to the back of the wall or side of the bin, at the angle of friction of the granular mass upon the material of the wall or bin. There are exceptions, but I have noted them carefully in "Practical Designing of Retaining Walls," and need not give them here. It may be well to state here that all French engineers and writers, as far as I know, take account of the wall friction in the way mentioned.

(6) The indirect proof of the above method, by considering retaining walls at the limit of stability, is of the highest scientific and practical value. In addition to the results of experiments given by me in the issue of Engineering News for March 3, 1898, two more experiments on surcharged walls may be cited.

The first is by Curie ("Poussée des Terres"), and refers to a vertical rectangular wall made of Portland cement, backed by damp sand, whose angle of repose was 45°. The angle of friction of wall on sand was 35°. The width of wall was 0.755 ft., its height 2.952 ft.; the surcharge extended entirely over the top of the wall, the surface slope being 45° up to a point 4.26 ft. above the top of the wall. Including the full wall friction at the back, as above outlined, a graphical construction gives finally, for a ratio of weight of earth per cubic unit to that of wall = 0.62, the resultant of earth thrust, weight of wall and earth over it. The center of pressure on the base is found

to be 0.02 width of wall inside of the outer toe or almost exactly through it.

The old theory which ignores the wall friction or supposes the back of the wall perfectly smooth, gives a resultant on the base passing half the width of the wall outside of the base, which is absurd, as the wall was stable, though just at the limit of stability.

(7) The second experiment is by Leygue on a very small vertical wall 0.1 ft. wide, 0.285 ft. high, with a surcharge of sand commencing at the back, at the top of the wall and sloping upwards at the angle of repose 33° 42', which is also the angle of friction of earth on wall. The ratio of the weight per cubic foot of earth to that of wall is 1.25.

Including the wall friction, the center of pressure on the base is found to lie 0.07 of the width of the wall inside the base from outer toe. For an older theory which ignores the wall friction altogether, the center of pressure is found to lie 0.7 of the width of the base from outer toe outside of the base. Some authors take, for simplicity, the coefficient of friction of earth on wall always the same as that of earth on earth, which is frequently inexact.

(8) A light, empty box whose width is slightly greater than its height and of any length whatsoever, will sustain a mass of sand placed against one side of the box if it is prevented from sliding by a small obstacle placed at the outer edge which does not impede rotation. If the surface of the sand is horizontal; the thrust against the side of the box should be horizontal by the Rankine theory, and overturning should occur if the weight of the wall is negligable. This simple experiment thus proves that wall friction is always exerted.

In conclusion, from a consideration of every kind of experiment, direct and indirect, given above and in my previous letter, it would seem that my contention that the full amount of "wall friction" should ordinarily be considered, is established.

Wm. Cain, M. Am. Soc. C. E.

Chapel Hill, N. C., April 18, 1898.

(The whole subject of pressures against retaining walls and flat surfaces in general has been so fully discussed in engineering literature that with this letter we shall close, as far as our correspondence columns are concerned, all further theoretical discussion on this point. Our columns, however, are still open to record actual experiments made to determine the extent and nature of pressures against flat surfaces, and, also, to a further discussion of the pressure of granular masses against curved surfaces.—Ed.)

Notes and Queries.

O. C. B., Fulton, N. Y., asks: "Which give better results for brick paved streets, vitrified bricks 2 × 4 × 8 ins. or 4 × 4 × 8 ins.?"

There is a great variety in the sizes of paving bricks, but thus far experience has shown, we believe, that bricks about the size of the common building brick give better results than the larger bricks, or blocks, as they are often called.

CLEANERS FOR THE LARGE OUTFALL SEWER AT SALT LAKE CITY, UTAH.

The sewerage system of Salt Lake City, Utah, has been fully described in our issues of Jan. 4, 1894, and March 8, 1897. One of the main parts of the work is an outfall sewer 42, 48 and 64 ins. in diameter, in different sections of its length. Devices for cleaning this sewer have been designed by Mr. F. C. Kelsey, City Engineer, to whom we are indebted for blue prints and notes regarding the same. Of the three prints sent by Mr. Kelsey we have selected for reproduction the one showing the cleaner for the 48-in. section. The other cleaners are similar in design, but that for the 64-in. section is flatter in cross-section, its outer edge being made up of two arcs of circles having radii of about 31 ins. each. Mr. Kelsey has described the cleaners in a letter addressed to us on Jan. 19, 1898, as follows:

The small cleaner was made first, and upon trial it was found that it would go around the curves in the sewer much better if the wheels were placed in front of the rim and the number increased to eight. This change was made on the 42 and 48-in. cleaners, as shown in dotted lines on the illustration. Two of the curves in the sewer have a radius of 90 ft.; the others have a radius of 127.32 ft. The cleaner for the 64-in. section is not the full size of the sewer, but it does the work as well as the others.

Manholes large enough to admit the cleaners were constructed at the points where the size of the sewer changes. The cleaners are handled with a light derrick, set up over the manholes.

The manhole covers now used in sewer construction are provided with pans for catching the dirt that falls through the perforated lids, but the old ones are not, and considerable dirt and gravel washes through them into the sewer.

The cleaners are run through the sewer about every three weeks and work very satisfactorily. The sewage backs up behind the cleaner until the head is sufficient to force the machine along, and the water rushing around the edge of the rim removes the slime and washes the sand, gravel and sediment along ahead of the machine. Ordinarily the cleaners travel at the rate of 100 ft. per min., but at times the sand and gravel is about 8 ins. deep for a distance of 100 ft., ahead of the machine, when they move much slower.

THE NICARAGUA CANAL ENTERPRISE.

In "Harper's Magazine" for May, Col. Wm. Ludlow, U. S. Engineer, has an interesting discussion of the "Trans-Isthmian Canal Problem," in which he tells the history of projects for canals across the Central American Isthmus since the middle of the Sixteenth Century. Col. Ludlow describes in detail the Panama enterprise; but the part of his article of greatest interest is that in which he discusses the present Nicaragua enterprise. We reprint part of this, as follows:

The Commission (of three engineers, of which Col. Ludlow was a member—Ed.) believed a ship canal project entirely feasible, but found it necessary to withhold approval of several features of the company's plans, and in particular deemed it prudent to double the estimate of cost, viz., from $67,000,000 to $133,500,000, as representing the minimum sum that could safely be charged to the construction, administration and contingent account—this estimate not including some possibly large sums as damages for submerged lands, and the like, for the computation of which no data were at hand, and for other charges incidental to the maintenance of the concession.

The company's project, based partly on the surveys in 1852 and 1873 by Childs and Lull, supplemented by additional surveys made under its own direction at intervals between 1887 and 1893, embodied constructions of a formidable and unprecedented character, the execution and maintenance of which, if deemed practicable, would involve heavy expenditures and be invested with serious hazards. The lake was to be raised to 110 ft. elevation, and the summit-level extended in both directions with a length of 155 or 160 miles, the total distance from Greytown to Brito being about 175 miles. To effect this, two immense dams were projected, one across the San Juan River at Ochoa, 70 miles below the lake, and the other at La Flor, less than 4 miles from the Pacific, where the valley of the Rio Grande was contracted between hills.

The La Flor dam will convert the upper Rio Grande Valley into a basin 4½ miles long, to be connected with the Pacific by 3 locks and a short canal, and with the lake by 9½ miles of canal excavated through the low range of hills which constitute the west divide, with a maximum depth of cutting of 75 ft.

The dam was designed with a length of 2,000 ft., and would have to sustain a head of water of 90 ft. The company proposed to build it of loose rock backed with clay, and later changed this to a concrete core, with stone and earth embankments on both sides; but as borings on the site showed that no solid foundation existed, it would be prudent to abandon the dam-and-basin scheme, and have recourse to a low-level canal, which would involve no difficulties in construction.

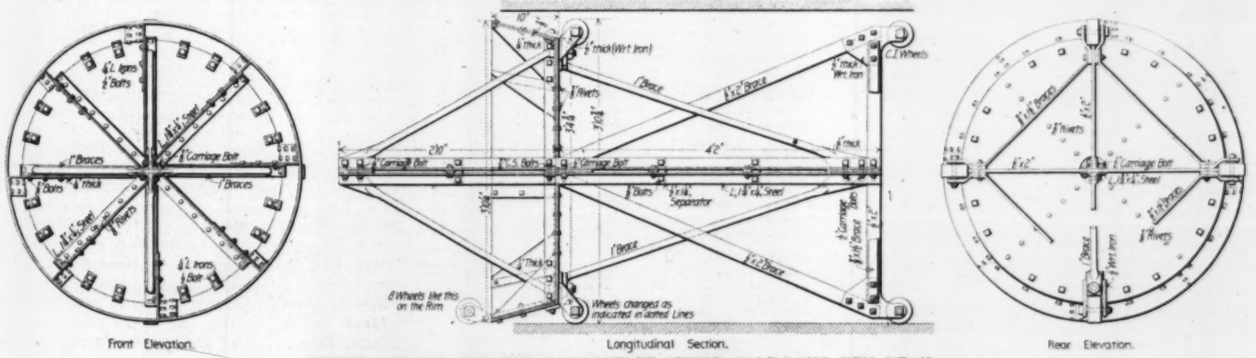
The Ochoa dam was to raise the San Juan River to the summit-level, and thereby effect a canalization of the entire distance of 70 miles to the lake, saving a large amount of excavation in the river-bed for the ship-channel, designed at 28 ft. depth. The dam would be 1,900 ft. long, and have to sustain a head of 60 ft. It had to be built in the bed of the stream, and subject to the action of the floods. The company proposed to build it of loose stone, backed with smaller materials and clay, with the expectation that it would be tight enough to maintain the head of water, and at the same time endure the passage over its crest of such floods as the river might discharge. As the bed of the river is sand to an unknown depth, and there were indications that the floods—which had never been measured—might reach as much as 150,000 cu. ft. per second, it is doubtful if these expectations could be realized, as a structure for such purposes is without precedent or comparison.

Assuming the maintenance of the summit-level as proposed, the canal was to leave the river at the dam and direct itself for Greytown, 30 miles distant.

The summit-level was to be carried 12 miles through the San Francisco basins, an intricate region of clay hills and mud bottoms, by means of an extensive series of 67 clay dams, some of great magnitude, one of them 1¼ miles long, with a height of 100 ft. above its foundations. It is not easy to see how, under the tremendous rainfall prevalent in their vicinity, these huge masses of clay are to be either constructed or maintained. Passing the embankments, the canal winds through the east divide—a rock and clay mass over 3 miles across, with a maximum cut of 324 ft., in materials shown by the few borings made to be of all degrees of hardness, from trap to volcanic ash, in which the side slopes are designed as five vertical on one horizontal. Thence the canal descends the valley of the Deseado, with 3 locks separated by short canals and basins, and reaches tide-level 9½ miles from Greytown.

It is evident that with constructions so novel and formidable, and conditions so difficult, the utmost care must be given to the procuring and study of all obtainable facts, including complete hydraulic and geologic data, variations of lake and river levels, velocity and volume of streams, quantity of rainfall at different points, violence and frequency of floods, and all the other detailed and particular information the engineer requires for the completion of his project, the preparation of his plans and estimates, and the drafting of his specifications. In the case of Nicaragua, as of all the other Isthmian projects, the information of this nature is still scanty and incomplete, and the materials composing the bed of the San Juan River for the 30 miles over which large underwater excavations were necessary have not been investigated at all. The project as formulated by the company is manifestly in its preparatory stage only.

The fact is that the possibilities affecting the final location between the San Juan River and the sea have been but superficially examined. The sandy bottom, marshy banks, and turbulent volume of the river through the low-lying delta furnish serious obstacles to the creation of a deep channel following its main course down the Colorado. On the other hand, the company's ambitious high-level project as above indicated presents equally obvious difficulties and special dangers. But it has not been shown that we are in fact restricted to these alternatives, and it is quite possible that a conservative middle course would be at once safer and less costly. For example, at Machuca Falls, 18 miles above Ochoa, a rocky reef crosses the river valley, and the construction of a high dam with locks would be quite practicable. A low dam and lock at Ochoa, and another at a site farther down, would carry the navigation to a point whence it could



DETAILS OF CLEANER FOR 48-IN. OUTLET SEWER, SALT LAKE CITY, UTAH.
P. C. Kelsey, City Engineer.

proceed at the low level direct to Greytown, substantially as projected by Childs. For the solution of these and other similar problems, a thorough investigation and accurate data for comparison are needed before the question of final location can be settled.

In accordance with the recommendations made by the commission of 1895, Congress, in the act of June 4, 1897, has provided for a second commission to finish the investigation and make final plans and estimates.

This commission is now in the field fully equipped for its work, and there is reason to believe that within a year or two it will be possible to decide how the Nicaragua canal should be built and what it will cost, and which of the two great rival projects, Panama or Nicaragua, will be the first to get itself completed, and constitute the most notable achievement in the annals of engineering.

CONSOLIDATION FREIGHT LOCOMOTIVE; SOUTHERN RY.

Some heavy consolidation freight engines have recently been built for the Southern Ry., according to designs prepared by Mr. W. H. Thomas, Superintendent of Motive Power, and in these designs special attention has been given to strengthen parts which have developed weakness in former engines of this type, and also to reduce the weight as far as possible without weakening any of the parts. The boiler is of the extended wagon-top pattern, with only a single course of cylindrical barrel, the sand-box being mounted on this part of the boiler, while the dome is on the front sheet of the wagon top. The cylinder saddles have heavy flanges for the bolts, and are double-bolted to the smoxebox, which is reinforced on the inside at the point of attachment. The piston rod has a taper fit secured by jamnuts, thus avoiding the key and key slot, which are considered objectionable. The crossheads are steel castings of the railway company's standard pattern, fitted with two-bar guides on the "alligator" style. The main rods are of I-section, and the side rods of rectangular section, of uniform depth throughout, and have solid ends. Cast steel is used for the driving wheel centers and driving boxes, and the driving axles and crank pins are also of steel. The main crank pins have journals 6 × 6 ins., the intermediate pins 7 × 5 ins., and the front and back pins 5 × 3¼ ins. Blind tires are fitted to the second and third (main) pair of driving wheels.

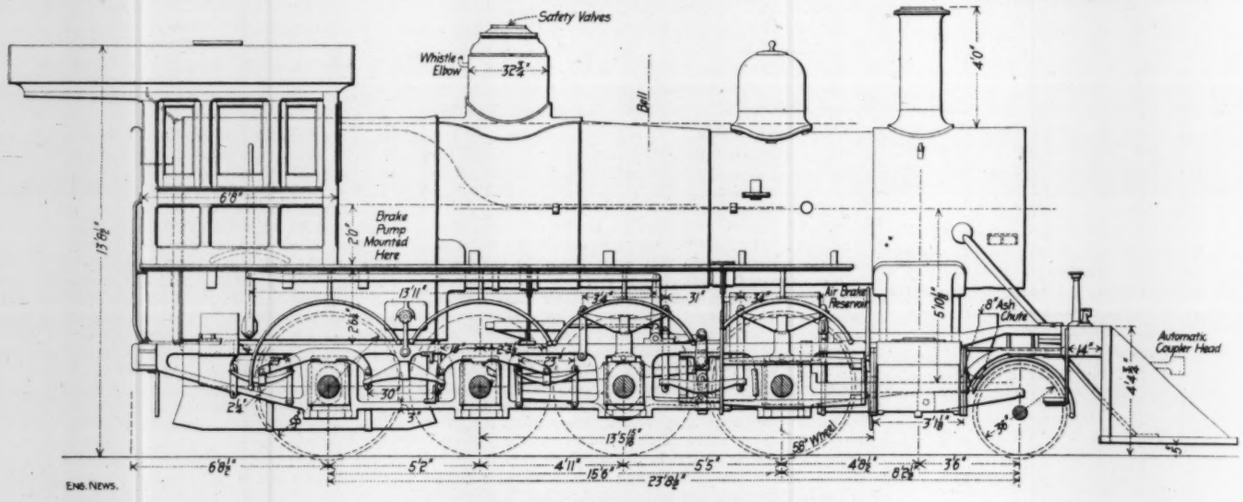
Some interesting features are to be noted in the equalizer rigging. The first two driving wheels have semi-elliptic springs over the boxes, the inner hangers being connected by equalizers, while the front hangers carry the end of the radius bar of the truck. Over each of the boxes of the two rear axles is a curved yoke or lever, the inner ends of which are connected by hangers to the ends of an inverted semi-elliptic spring below the top member of the frame, while the outer ends are attached to the straps of light semi-elliptic springs, whose hangers are supported by the bottom member of the frame. The link motion is between the first and second axles, and the eccentric rods are bent to clear the second axle. The engines will burn bituminous coal.

Heavy draft gear automatic couplers is used, the heaviest type of Janney-Buhoup three-stem coupler being on the tender and a Janney coupler head on the draw bar projecting through the engine pilot. The tender has a frame of steel channels, and is carried on two trucks with diamond frames. The Westinghouse-American outside equalized brake is applied to the driving wheels, and the Westinghouse brake to the tender wheels. The fittings include the Golmar bell-ringer and the Leach compressed air sand jet.

The engines were built by the Richmond Locomotive & Machine Works, of Richmond, Va., to whom we are indebted for drawings and information, and the following is a list of the leading dimensions:

Dimensions of Consolidation Freight Locomotive; Southern Ry.

Running Gear:	
Driving wheels (8), diameter	4 ft. 10 ins.
Truck wheels (2), "	3 " 0 "
Tender wheels (8), "	2 " 9 "
Driving wheel centers	Cast-steel
Truck wheels, steel tired; tender wheels	Cast-iron.
Driving-wheel tires secured	By shrinkage.
Engine truck	Swing center.
Journals, driving axles	8½ × 10 ins.
Wheel Base:	
Driving	15 ft. 6 ins.
Total engine	23 " 8½ "
Tender	17 " 1 "
Engine and tender	47 " 9½ "
Truck-pin to center of lead. driv. wheel	8 " 2½ "
Wheels having blind tires	Second and third drivers.
Weight in Working Order:	
On driving wheels	133,650 lbs.
On truck wheels	18,000 "
Engine, total	151,650 "
Tender, empty	37,830 "
Loaded	86,830 "
Water in tank	35,000 "
Water in boiler	18,000 "
Coal on tender	6¾ tons.
Does counterbalance conform to M. M. Assoc. rules	Yes.
Weight of piston	333 lbs.
Piston rod	170 "
Weight of crosshead	223 "
Main rod	563 "
Side rod	683 "
Cylinders:	
Number	Two.
Diameter and stroke	21 × 28 ins.
Cubic contents of all cylinders	11.22 cu. ft.
Form of crosshead and guides	Two-bar; So. Ry. standard.
Connecting rod, length between centers	10 ft. 6 ins.
Side rod	Solid ends.
Valve Gear:	
Type	Shifting link.
Ports, steam	1⅛ × 18 ins.
Ports, exhaust	3 × 18 "
Bridges, width	1¼ "
Eccentrics, throw	5 "
Slide valves	American balanced.
" " maximum travel	5½ ins.
" " inside line and line; outside lap	1 "
" " lead (full forward & backw'd gear	1-16 "
Boiler:	
Type	Extended wagon top.
Diam. barrel, inside smallest ring	4 ft. 11⅝ ins.
Dome, diam	2 " 8¾ "
Thickness, barrel plates	⅝ "
Smokebox tube-plate	½ "
Horizontal and circumferential seams	Double riveted.
Joints	Butt.
Rivets, diameter	1-in.
Height from rail to center line	8 ft. 4¾ ins.
Length of smokebox (including extension)	5 " 11⅞ "
Does smokebx arrangem't conform to M M.A. rules?	Yes.
Spark arresting device	Ext. front, deflector and netting.
Injectors, number	Two.
Kind	No. 10 and No. 11 Monitor.
Working steam pressure	200 lbs.
Firebox:	
Type	Above frames, radial stayed.
Length inside	8 ft. 9⅛ ins.
Width inside	9 " 0⅛ "
Depth at front	5 " 8¾ "
Depth at back	5 " 5¼ "
Thickness, side plates	⅜ "
" back plate	⅜ "
" crown plate	⅜ "
" tube plate	½ "
Crown stays	Radial.
Grate bars	Cast-iron. Rocking.
Is fire-box arch used	Yes.
Stay bolts (drilled), diameter	1 ins.
Pitch	4 ins.
Water, spaces, width at front	4 "
At back and sides	3½ "
Tubes:	
Material	Cleveland iron.
Number	271
Thickness	No. 12 B. W. G.
Pitch	2 11-16 ins.
Diameter, outside	2 "
Length over tube plates	14 ft. 4 "
Total area of tube openings	4.70 sq. ft.
Heating Surface and Grate Area:	
Heating surface, tubes (exterior area)	2,008.11 sq. ft.
" " firebox	158.00 "
" " fire-brick arch tubes	17.14 "
" " total	2,183.25 "
Grate area	20.88 "
Ratio of total heating sur. to grate area	73.07 "
Ratio of int. tube area to f'box h't'g sur.	12.82 "
Total heat. sur. to 1 cu. ft. of cyl. vol.	194.66 "
Firebox heat. sur. to cu. ft. of cyl. vol.	14.04 "
Tube heat. sur. to 1 cu. ft. of cyl. vol.	180.60 "
Grate area to 1 cu. ft. of cyl. vol.	2.66 "
Miscellaneous:	
Exhaust nozzle (single), diameter	5¾ ins.
Exhaust nozzle, distance above c. l. of boiler	14½ "
Smokestack, diameter at top and base	16 "
" height above smokebox	4 ft. 0 "
" height of top above rail	15 " 0⅝ "
Capacity of tender tank	4,200 gals.
Capacity of coal space	13,500 lbs.
Brake fittings on engine	Amer. outside equalized.
" " on tender	Westinghouse.
Tract. force per lb. of effective press. on pis on	212.90
Total tractive force with effective pressure equal to 85% of boiler pressure	36,190
Total adhesive p'wr at ¼ of w'g't on driv'g wheel	33,413
Ratio of tractive force to weight on driving wheel	0.270



CONSOLIDATION FREIGHT LOCOMOTIVE; SOUTHERN RY.
Richmond Locomotive Works, Builders.

NOTES FROM CITY ENGINEERS' AND OTHER MUNICIPAL REPORTS

Metropolitan Sewerage Works, Boston and Vicinity.—These works now include three distinct systems of main intercepting sewers, having a total length of about 65 miles, and serving some 20 separate municipalities. The North Metropolitan System is mainly in the valley of the Mystic River, and discharges into the sea at Deer Island. The Charles River and the Neponset River Valley Systems connect with the Boston Main Drainage System, with ultimate discharge into the sea at Moon Island. All of the sewage is pumped, that from the Charles River and Neponset systems being pumped by Boston. On the North Metropolitan System there are four pumping stations. Each of the three largest stations have two submerged centrifugal pumps, driven by Reynolds-Corliss triple expansion engines, specially designed and erected by the E. P. Allis Co., of Milwaukee, Wis. At both Deer Island and East Boston there are two 45,000,000-gallon pumps, 8¼ ft. in diameter, with nominal lifts of 12 and 16 ft. respectively. At Charlestown there are two 22,000,000-gallon pumps, 7½ ft. in diameter, with a nominal 8-ft. lift. At each of these stations the

force employed is three engineers, three firemen, three screenmen, and one reliefman. First quality of Cumberland coal was used at each of these stations, costing from $2.76 to $3.05 a ton. The average duty at the several stations was 61,000,000 ft.-lbs. at Deer Island, and 56,000,000 at both East Boston and Charlestown. The average daily pumpage of sewage was 32,000,000 gallons at Deer Island, 30,000,000 at East Boston, and 21,000,000 gallons at Charlestown, the average lifts being 10.83, 14.81 and 7.9 ft., respectively. At the Alewife Brook station the plant consists of two 9-in. Andrews vertical centrifugal pumps, with direct-connected compound marine engines. Each pump has a daily capacity of 4,500,000 gallons and a nominal lift of 13 ft. The average duty for the year was 15,000,000 ft.-lbs., and the average daily pumpage was 2,540,000 gallons. The force employed consisted of two engineers, working in twelve-hour shifts. The coal burned was first quality Cumberland, costing from $3.43 to $4.07 per ton. The detailed cost of pumping at the four stations for the whole year, expressed in cents per 1,000,000 gallons raised 1 ft. high, was as follows:

	Deer Island.	East Boston.	Charlestown.	Alewife Brook.
Labor	5.09*	4.13	10.92	20.44
Coal	1.96	2.16	2.44	9.28
Oil	0.26	0.24	0.65	1.88
Waste	0.03	0.03	0.08	0.19
Water	0.36	0.44	0.41	0.75
Packing	0.11	0.05	0.08	0.10
Miscellaneous	0.79	0.68	1.62	3.40
Supplies and renewals	..	..	..	..
Total	8.60	7.73	16.20	36.05

*Deducting labor at screens the cost would be 3.83 and 3.33 cts. at Deer Island and East Boston, respectively.

At all the stations it is expected that the unit cost of pumping will be lower hereafter, as the pumping was light the first half of the year. The conditions at the two smaller stations will continue to cause a higher cost per unit than at the others. It will be seen that labor is the great item at the Alewife Brook plant, although only two men are employed, one for day and one for night service.

The above information was taken from the ninth annual report of the Metropolitan Sewerage Commission, of which Mr. Wm. M. Brown, Jr., M. Am. Soc. C. E., is Chief Engineer, with offices at No. 1 Mt. Vernon St., Boston, Mass.

The relative advisability of contract and city labor for sewer construction is discussed by Mr. F. Herbert Snow, Assoc. M. Am. Soc. C. E., in his last report as city engineer of Brockton, Mass. In 1894 all sewer work was done by contractors, but bids were made under the alternatives of employing such men, and at such prices, as the contractors saw fit ($1.25 to $1.50 for ten hours), and of hiring only city laborers at $2 for a day of nine hours.

The total cost of sewer work in 1894, by contract, the work being on 26 streets, or parts of streets, was $35,984, of which $21,546 was for labor and $14,439 for material. If city labor had been employed, supposing the same number of men to have worked for the same length of time, the cost would have been increased by $7,119, or 20% on the cost of both material and labor, and about 33% for labor alone. Engineering, inspection and legal fees are not included in these figures, and probably advertising charges are also omitted. The range of increased total cost was from 14 to 28%, both extremes being for streets which cost less than $400 for labor and material, against an average cost of $1,345 for each of 26 streets. The bids of seven contractors on the work of this season ranged from 15 to 62% higher for city than for contract labor, on the total cost of the work.

In 1895 the city instructed the contractor to use city labor on a sewer 2,461 ft. long, with an average cut of 13 ft., and a maximum cut of 21½ ft. The excavation was in "fine, loose sand, free from water," over three-fourths of which, in length, had to be close-sheeted. The average price paid by the contractor for common labor on his other work was $1.40 per day of ten hours, against $2 for a day of nine hours paid the city laborers on this job. The total cost of labor and material was $5,747, or 27% more than the work would have cost if the contractor had furnished his own labor. The contractor lost money on the job. He claims this was due to the use of city labor, but Mr. Snow maintains the contrary.

In 1896 the city did all its own sewer work without contractors, at a cost of 52% in excess of the contract prices of 1894, and in 1897 it pursued the policy at an extra expense, on the same basis, of 30%, or of 23% if a piece of work more difficult than any done by contract be excluded. With the exception of this difficult piece of work Mr. Snow thinks the general character of the work done by the city in these two years was about the same as that done by contract in 1894. He expresses no opinion regarding the relative cost of contract labor during the two periods, evidently assuming that the contractors, had they been given a chance, would have taken the work at as low a price in 1896 or 1897 as they did in 1894.

Some of Mr. Snow's conclusions regarding the four years' experience are as follows:

> The adoption of city labor has given satisfaction and it will be continued. While the direct cost at first is somewhat greater, there are certain indirect features which have a most important bearing in favor of the system. The employment of citizens who would not otherwise have work results undoubtedly in the circulation of almost all their entire wages within the city limits, gives the city an opportunity to secure and permanently retain a number of picked men who are particularly careful or efficient on certain kinds of work requiring extra care and skill, and probably tends to obviate the necessity of charitable disbursements. At the Brockton price ($2 for nine hours, against $1.25 to $1.50 for ten hours paid by contractors.—Ed.) the laborer can earn enough to support his family in fair shape, and save a little besides. The employment of city labor also precludes the possibility of lawsuits from contractors, and the engineering expenses are also reduced.

As to the relative quality of city and contract work, Mr. Snow says, "there should, in our opinion, under the same engineer, be no difference." At Brockton "the city furnishes all materials upon which there might be a chance to cheat." Therefore, the difference between the cost of contract and city labor must lie in the labor itself, including both its price and the amount done. The common city labor costs about 50% more per hour than the wages paid to Italians for the same class of work. On the average, labor makes up about 60% of the contract price for sewers in Brockton, and about 70% of all the labor can be done by men working at the minimum rate, or 42% of the total cost of a sewer. If the rate of wages to these men is increased by 50%, the total cost of the work will be raised 21%, provided (1) that the raise in the lowest grade of wages does not necessitate a raise all the way up the scale; and (2) that the increase in wages is not accompanied by an increase in the amount of work done. Mr. Snow believes that if wages are increased at the bottom of the scale some increase must be made at least in the class of men just above ordinary laborers. As to the relative amounts of the same class of work done by Italians and the higher-priced city laborers, Mr. Snow says:

> Many claim that the better paid man, being better fed, more intelligent and of better physique, can do more work. It must be borne in mind, however, that where intelligent work is required we hire a certain number of men to do it. On the other work it is almost impossible to use any great degree of intelligence, and our experience has not led us to conclude from the figures on sewers that the better paid common laborer does any more work, although we have no doubt that in case of great emergency he would be able to. The fact that contractors hire Italians almost exclusively for this class of work is pretty conclusive evidence that it is cheaper. From our experience we cannot take the stand that city labor is cheaper on first cost. * * * The issue has been fairly met and settled by this department, not upon the assumption that city labor is cheaper, but upon the broader basis of sound public policy.

All sewer work at Brookline, Mass., was done by day labor in 1897, under the general direction of the city engineer, Mr. L. M. Hastings. Some details of the cost and character of this work are given by Mr. Hastings in his last annual report, but nothing is said regarding the relative merits of city and contract work.

The city of Haverhill, Mass., takes photographs and measurements in connection with all accidents for which claims are liable to be brought against the city. Mr. Robt. R. Evans is city engineer.

The last annual report of Mr. Otis F. Clapp, City Engineer of Providence, R. I., contains the accompanying statement of the average depth of cut, nature of excavation, and contract cost of labor per foot on the different sizes of sewers built in Providence in 1897.

Brick was the principal material used for paving work in Albany, N. Y., during 1897. Where granite was used the gutters were paved with brick. The brick gutters lessen the cost of paving and of street cleaning somewhat, and are greatly appreciated by wheelmen.

During the year, the city engineer, Mr. Horace Andrews, M. Am. Soc. C. E., made the necessary calculations and designs and superintended the placing of a meridian mark in the sidewalk close by the city hall, and a vertical sun dial on a tablet in the wall of the city hall, the tablet also giving the latitude and longitude of the finial of the city hall tower. The meridian mark and tablet were suggested, and their general character indicated by the mayor of Albany, Mr. John Boyd Thacher. They are described by Mr. Andrews in his report as follows:

> The meridian mark was constructed by the Schilling Co., of this city. It is a strip of rolled brass, 67½ ft. long and 6 ins. wide, inlaid in slabs of Brandon (Vt.) marble 2 ft. wide and 6 ins. thick. The marble rests on a foundation of Portland cement concrete 2 ft. wide and 1 ft. in depth. The brass strip is composed of pieces about 10 or 12 ft. long, which are attached to the marble by dove-tailed brass seats, inlaid so that the brass can expand freely and at the same time cannot be removed from its position.
>
> Our main streets, following the directions of the old city boundaries, run at an angle of nearly 45° with the meridian, and many of the citizens take an interest in examining the meridian mark and fixing their ideas of the direction of the cardinal points.
>
> * * * * * * * *
>
> The true meridian was fixed by the city engineer in

Cost of Sewers Per Foot in Providence, R. I., in 1897.

Items.	Average Nature of excavation.	Average Depth of cut, ft.	Average Cost per ft.
6-in. pipe in drains to curb line	Fine sand, dry	10.50	$0.47
	" wet	10.50	.50
	Sand and gravel, dry	10.50	.45
	" " wet	10.50	.40
8-in. pipe in basin connections	Fine sand, dry	8.00	.46
	" wet	8.00	.50
	Sand and gravel, dry	8.00	.43
	" " wet	8.00	.45
	Rock (additn to stipulatd price)	8.00	.40
8-in. pipe in sewer	Fine sand, dry	11.67	.74
	" wet	11.67	.60
	Sand and gravel, dry	11.67	.72
	" " wet	11.67	1.20
	Rock (additn to stipulatd price)	11.67	.45
12-in. pipe in sewer	Fine sand, dry	12.00	.75
	Sand and gravel, dry	12.00	.76
	" " wet	12.00	.70
	Filling, wet	12.00	1.65
	Rock (additn to stipulatd price)	12.00	.01
15-in. pipe in sewer	Fine sand, dry	12.25	.85
	Sand and gravel, dry	12.25	.78
	Filling, wet	10.33	.60
	Marl and boulders, dry	13.00	.80
18-in. brick sewer, single course	Sand and gravel, dry	12.50	1.00
	Marl and boulders, dry	13.50	1.50
20-in. " "	Fine sand, dry	12.67	1.00
	Sand and gravel, dry	12.67	2.50
24-in. " "	" " "	13.00	1.00
26-in. " "	Fine sand, wet	12.25	3.00
	Sand and gravel, dry	13.17	2.00
28-in. " double course	" " "	13.33	3.50
30-in. " "	" " "	11.75	2.25
34-in. " "	Fine sand, wet	12.50	4.50
38-in. " "	" " "	10.00	4.00
48-in. " "	Sand and gravel, wet	13.50	3.00
24x36-in. " "	Marl and boulders, wet	14.00	10.80
Average cost of building	348 manholes, each	.....	11.26
	136 catchbasins, each	.....	7.79*
Rock excavation, per cubic yard, extra (stipulated price)	19 extra inlets, each	.....	4.00
	....	.....	....

placing the brass strips by deducing the true azimuth from the triangulations of the United States Coast and Geodetic Survey, and the State Survey, and checking this direction by two series of azimuth observations on the sun, under favorable conditions. The direction of the true meridian was thus determined more accurately than it was possible for the workmen to set the brass strips.

The latitude and longitude are geodetic, being derived from the United States Coast and Geodetic triangulation, through the city triangultaion. They represent averages from determinations at sixty stations throughout the entire eastern coast of the United States, and differ a small amount from the geographical positions astronomically determined at the Dudley Observatory. The discrepancy differs little from the value deduced by the Coast Survey computers.* It was thought best to use the geodetic rather than the local astronomical latitude and longitude, so that comparisons could be more readily made and distances be more accurately computed between distant points throughout this and other States, the geodetic positions of a large number of such points having been determined by Federal and State triangulations.

The bronze tablet was very carefully made by Haight & Clark, of this city. The computations for the vertical declined sun-dial were made by the City Engineer, who supervised its construction. The work was admirably done by the founders. The dial is of plain bronze and the style was constructed and placed with great care. The dial gives true solar time for the seventy-fifth meridian, so that standard eastern clock time can be derived by merely applying the equation of time, the values of which for the entire year are placed on a small table near the dial. Time can be read from the dial within one or two minutes of its exact value.

The report of Mr. Chapman L. Johnson, City Surveyor of Utica, N. Y., for the years 1895 and 1896, though much delayed in time of publication through causes beyond his control, contains much information and many suggestions of interest to engineers and city officials. Pavements, assessments for improvements, sewers, electrical subways, a system of ensuring to the city that it does not pay for more electric lighting than it actually receives, forms of contracts, paving work done or left undone by street railway contractors and cement testing are some of the topics discussed. Regarding the advisability of testing cement, which had been tried for three years when the report was written, Mr. Johnson says:

> It is true that very little cement offered has been condemned, but this does not offer any argument against the advisability of the system. Nearly all the large cement manufacturers make and put upon the market different grades of cement. To corporations and municipalities who they know do not apply systematic tests they furnish the poorer grades; to those who they know will apply the tests, they furnish cement which will meet them, and the mere presence of the testing machine here and furnishing contractors with specifications clearly defining the qualities required is almost sufficient to secure the obtaining of a good article.

The city of Bridgeton, N. J., which by the census of 1890 had a population of over 11,000, being still without a sewerage system at the close of 1897, engaged Mr. Alexander Potter, Assoc. M. Am. Soc. C. E., of 137 Broadway, New York city, to make plans for a system of sewerage and sewage disposal. Early in 1898 Mr. Potter submitted a report and plans, which were accepted by the city. The report has been printed and shows that the separate system is proposed, with disposal by intermittent filtration. A small part of the sewage of the city will have to be pumped, and for this work electricity or compressed air, the latter being preferred, is recommended, with the power plant at the water-works pumping station.

One of the most artistic reports received by us year after year is that of the Board of Park Commissioners of Wilmington, Del. The reports are embellished with a few ornamental designs and handsome reproductions of well-chosen views taken in the parks. There were at the close of 1897, 246.6 acres of parks in charge of the board, made up of four parks ranging in size from 15 to 80 acres, and three small parks aggregating 17 acres. Besides these there are, outside the jurisdiction of the board, seven other small parks and open places, ranging from 7.5 acres to 0.09 acres in area, and aggregating 12.55 acres. The total park area is therefore 259.15 acres, out of a total city area of 10.18 sq. miles, thus making one acre of park land to each 26 acres of city area. The population is estimated at 70,000, giving one acre of park land to each 270 inhabitants. The 247 acres of park land in control of the board has been acquired at an expense of $217,369, or $880 per acre on the average. The total cost of maintaining the park system in 1897 was $8,741, including engineering, superintendence, police and lighting. Mr. Theo. A. Leisen is Engineer and Superintendent of the Park System.

*The astronomical latitude is here about 1.4 minute less than the geodetic, the zenith being locally deflected to the south by this amount. See report of the C. & G. Survey for 1897, p. 110.

One of the difficulties encountered at Baltimore, Md., in endeavoring to keep the streets in proper condition, is stated in the last annual report of Mr. Wm. A. Hanway, City Commissioner, to be "the neglect of street railways and their utter indifference to the requirements of the law regarding their duty to keep in repair streets between and 2 ft. outside their tracks." Mr. Hanway states that in 1897 he had an inspection made of the pavements along all the street railway lines in the city, and sent a list of places needing repair to each company, with a notice to repair. He adds that "a failure to respond promptly will bring upon them the penalties provided." Similar difficulties are spoken of in the Utica report, named above.

Brick paving on 2 ins. of sand and 6 ins. of concrete is preferred to asphalt by Mr. M. W. Manning, Commissioner of Public Works of Peoria, Ill. Asphalt laid in 1892 and 1893 has not given satisfaction, he states, and he believes brick is cheaper and more durable. Apparently the property-owners do not all agree with him, since they continue to choose asphalt, knowing that the cost will be assessed against them. Up to the close of 1897 nearly 27 miles of brick pavement had been laid in Peoria, against 9 of asphalt, and some three miles of cedar block, stone block and cobblestone. The commissioner maintains that local manufacturers can make as good paving brick as can be produced anywhere in the country, and at as satisfactory prices. He thinks it should, therefore, be apparent, brick being, as he claims, more durable and cheaper than asphalt, that it should be used in preference to paying "money to non-residents for an inferior pavement."

In the same report, Mr. A. D. Thompson, city engineer of Peoria, gives a description of the proceedings required to initiate public improvements under the act passed by the State Legislature in July, 1897. Under this system, which is the most cumbersome one ever brought to our notice, all schemes for improvement must originate with a Board of Local Improvements, composed of the Commissioner of Public Works, the City Engineer, Superintendent of Streets, Superintendent of Sewers, and Superintendent of Special Assessments. The board must first of all pass a resolution describing the proposed improvement, containing an itemized statement of its cost, signed by the engineer, and giving at least ten days' notice of a public hearing. After the hearing, if the board decides to proceed with the work, it must submit an ordinance, approved by a majority of its members, to the city council. If the council passes the ordinance, a petition must be made to the County Court for the levying of an assessment for benefits on account of the proposed improvement. The court thereupon directs the Commissioner of Special Assessments to assess the cost upon those benefited. When the figures have been made, 15 days' notice must be given for a hearing on the confirmation of the assessment by the County Court. If anyone urges that he has been assessed in excess of his benefits, the matter goes to a jury, unless waived by mutual agreement, the character of the agreement not being stated in the report. If after the hearing it appears that the assessment is insufficient, the Court may distribute the deficiency among other property benefited and another hearing must be had. After the assessment is confirmed 60 days must elapse before inviting bids, and ten days more before bids can be received, or 15 if the board chooses. Within 20 days after the reception of bids the contract must be awarded, if at all, and before the contract can be executed ten days must elapse during which the owners of a majority of the property fronting on the proposed improvement may, if they choose, take the contract at a price 10% below that named by the bidder to whom the award was made.

We do not wonder that Mr. Thompson characterizes this law as "cumbersome, complicated and unsatisfactory." It applies to all cities having populations of 25,000 or over (perhaps Chicago is exempt), and meets with disfavor in at least one other city, Evanston. Without allowing for the time taken to make the engineer's estimates, pass an ordinance through the city council, secure the necessary court order and make the assessment, at least 105 days are required by the time limits fixed by the law between the different stages of the proceedings. Adjournments and the time intervening between the meeting of one body and that of the next to act in these proceedings would still further prolong the time, while jury trials and reassessments would cause delays the length of which cannot be predicted. If the law outlined above is not soon repealed or amended we shall be surprised.

Day labor on street paving was tried in Minneapolis for the first time in 1897, and is described in the last report of Mr. F. W. Cappelen, M. Am. Soc. C. E., City Engineer. Early in the season some small jobs of brick paving had been let at from $1.73 to $1.84 per sq. yd. Later contracts for two alleys were awarded at $1.87, but on the same day the last bid was received the prices named for the work afterwards done by the city were $2.00, $2.02 and $2.04. Another call resulted in four bids, ranging from $1.90 to $2.04. The committee advised the acceptance of the lowest bid, but the council voted against it, and bids were again received. This time only two bids were submitted, at $1.99 and $2, respectively. The council then directed the city engineer to buy the necessary material and do the work by day labor. All the work named above was brick on 6 ins. of concrete, and the city work was done under the same specifications. The city bought 198 carloads of brick from the Purington Paving Brick Co., of Galesburg, Ill., at a net price of $15.54¼ per 1,000, equal to 87 cts. per sq. yd., with a guarantee to replace all defective brick for a period of ten years. Crushed stone for the concrete cost $1.00 to $1.27½ per cu. yd.; 1,992 bbls. of Milwaukee cement were bought at 75, and 1,296 bbls. of Mankato cement for 78 cts. per bbl. A contract was made with John Murphy, of Columbus, O., for filling and grouting the joints with Murphy grout at 17½ cts. per sq. yd. Mr. Cappelen says that

> owing to the unsatisfactory manner in which some of this material set up, only about one-half the work has been paid for, waiting until next season for final adjustment of some, as it was too late in the season to do anything about it at the time.

A ½-in. expansion joint of California asphalt and Maltha was placed about every 150 ft., extending from curb to curb. An average of 65 men were employed on the work, the minimum wages being $1.75 per day. The total amount paid out for labor was $4,585. The itemized cost of the job, per sq. yd., is as follows:

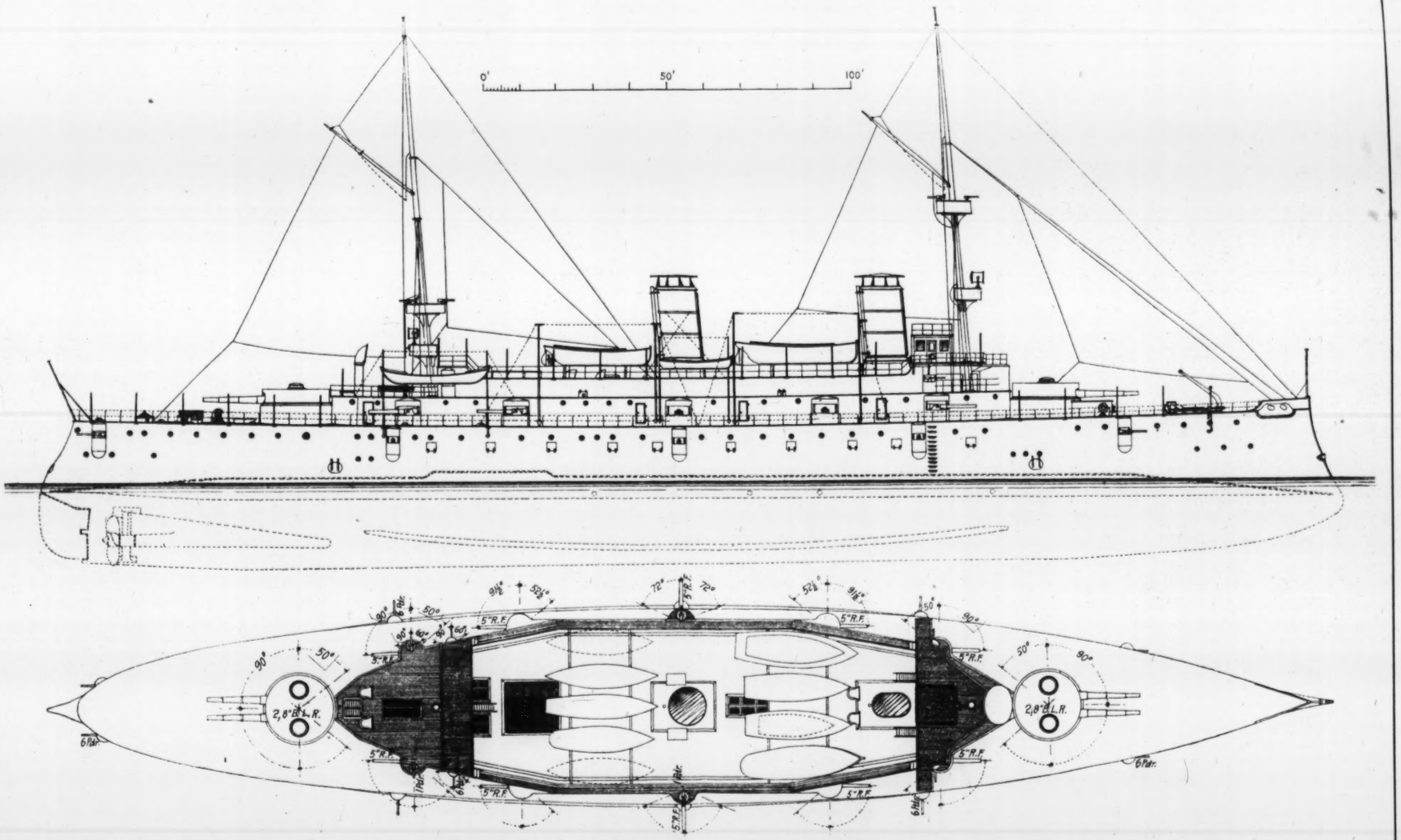
Removing old paving	$0.035
Grading	0.032
Concrete	0.467
Planking, concrete and miscellaneous	0.008
Brick	0.870
Hauling	0.038
Cushion	0.018
Laying brick	0.032
Murphy grout	0.175
Total	$1.675

This price of $1.675 per sq. yd. is 31½ cts. below the lowest bid on the last call, and saved the city about $5,400. The lowest price named in any of the three sets of bids, $1.90, was 22½ cts. per yd. above the actual cost by city labor.

The dilatoriness of contractors in making guarantee repairs to asphalt pavements leads Mr. Cappelen to suggest that the city consider the advisability of establishing a municipal asphalt plant. He states that asphalt can be bought at a fair price and laid in Minneapolis at $1.60 per sq. yd., including an allowance of 5% interest on an investment of $20,000 for plant and tools.

The principal cause of need of repairs to asphalt pavements, Mr. Cappelen believes, is excessive sprinkling. The total amount of water used for street sprinkling during the year was 366,000,000 gallons, besides which 3,000,000 gallons was used for flushing asphalt streets and 12,000,000 gallons by the Park Board. No charge was made for this water, but the regular meter rate charged private consumers of this amount would be 8 cts. per 1,000 gallons, amounting to about $30,500. This is nearly a third of the amount actually paid out as street sprinkling expenses, $105,685.

The report contains a considerable amount of matter relating to water-works improvements, some of which we hope to publish in a later issue.



THE UNITED STATES PROTECTED CRUISER "OLYMPIA," Flagship of the Asiatic Station.

Displacement, 5,870 tons.
I. HP., 17,313. Speed, 21.69 knots.

Armament: Four 8-in. B. L. Rifles in Turrets, Ten 5-in. R. F. Guns, Fourteen 6-pdr. R. F. Guns, Seven 1-pdr. R. F. Guns, Four Gatlings, One Field Gun, Six Torpedo Tubes.

Armor: 3½ and 4½ ins. on Barbette Turrets; Protective Deck, 4¾ ins. on Slopes, 2 ins. on Flat.

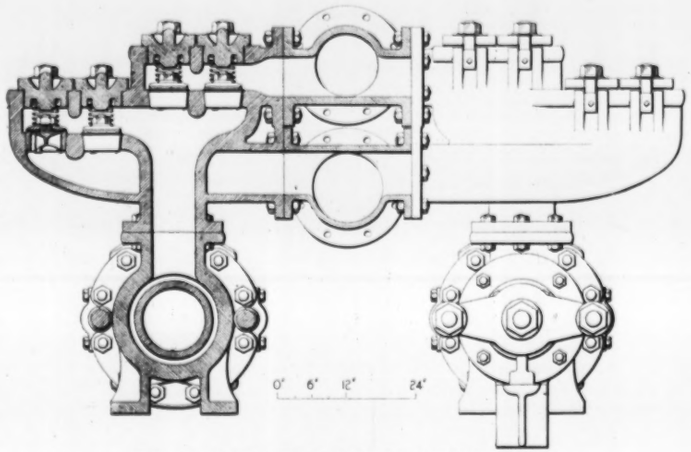


FIG. 4. TRANSVERSE SECTION OF WATER END.

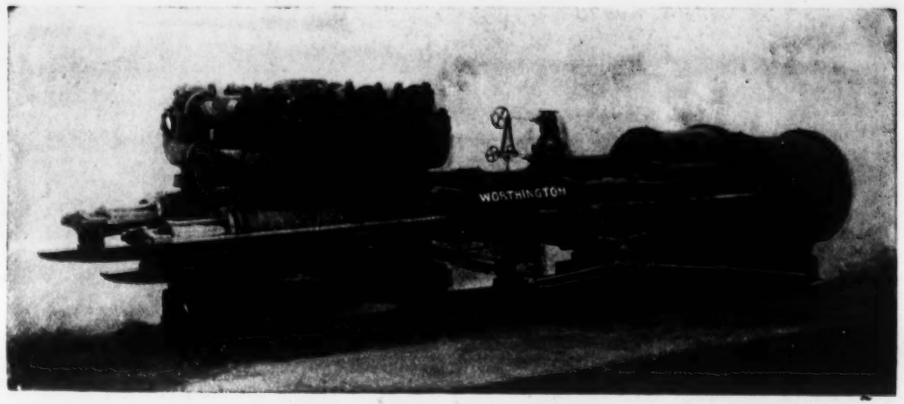


FIG. 1. GENERAL VIEW OF ENGINE.

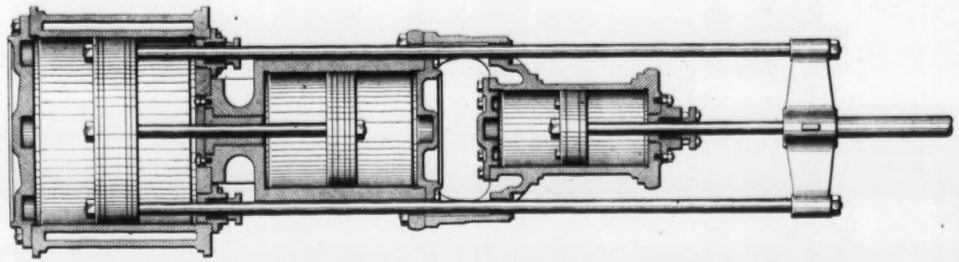


FIG. 2. HORIZONTAL LONGITUDINAL SECTION, SHOWING ARRANGEMENT OF PISTON RODS.

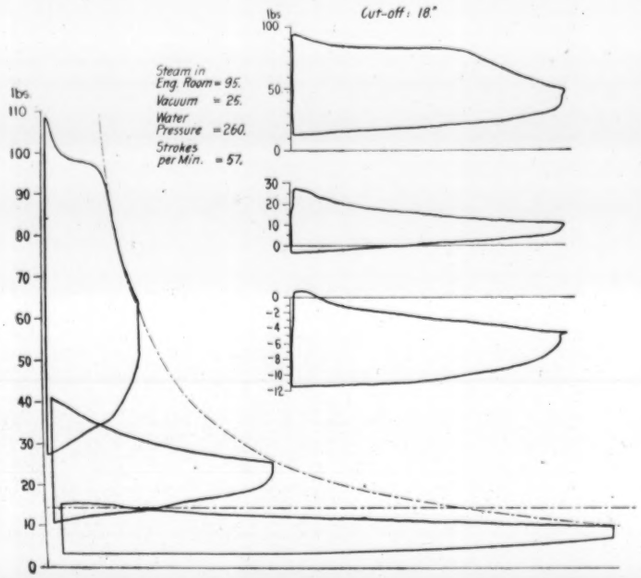


FIG. 5. INDICATOR DIAGRAMS FROM THE THREE STEAM CYLINDERS AND COMBINED DIAGRAM.

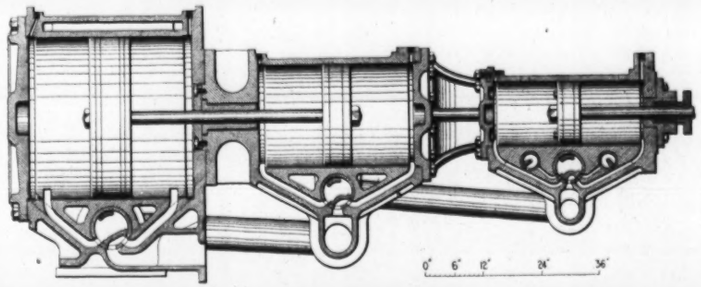


FIG. 3. VERTICAL LONGITUDINAL SECTION, SHOWING VALVES AND STEAM PASSAGES.

TRIPLE EXPANSION MINE PUMPING ENGINE FOR THE NEW JERSEY ZINC CO.

Designed and Built by Henry R. Worthington, New York.

At the close of this report Mr. Cappelen refers to the civil service agitation and states that thirty of the employees in his department have been there for an average length of 12¼ years.

The last report of the city engineer of Des Moines, Ia., contains special reports by Mr. Lafayette Higgins, City Engineer, and Prof. Chas. N. Kinney, Chemist, on new water-works for Des Moines. It now seems probable that the city will buy the plant of the Des Moines Water-Works Co.

Gas from leaky mains damages asphalt pavements at Montreal, P. Q., according to Mr. Percival W. St. George, City Surveyor. This conclusion has been reached after making tests of the asphalt.

THE UNITED STATES PROTECTED CRUISER "OLYMPIA."

(With full-page plate.)

We show on our inset sheet this week an elevation and plan of the flagship of the Asiatic fleet of the United States, whose battle with a Spanish squadron in Manila Bay on May 1 is now the chief topic of interest in naval circles throughout the world. The information at hand concerning the battle is at this time too meager to make any comment upon it from the point of view of the naval engineer. At present it can only be said that the marked superiority of the American vessels in armament, armor protection and speed, made the outcome of the contest a foregone conclusion, barring the accidental chances that may often decide a naval conflict and the problematical part that the fortifications on shore or mines and torpedoes in the waters of the bay might play.

The "Olympia," the flagship of the United States fleet on the Asiatic station, is one of the finest vessels in the Navy. She was built by the Union Iron Works of San Francisco, and on her official trial trip in 1893 made a speed of 21.686 knots, or only 1.387 knots less than the speed of the "Columbia" in her famous trial trip. She is really more heavily engined in proportion to her size than the "Columbia," her two engines indicating 17,313 I.-HP. against the "Columbia's" 18,-769. Her gross tonnage is 4,011, against 5,552 for the "Columbia." Her armament is, on the whole, more formidable than any other of our protected cruisers except the "Chicago." As seen by the plan view on our inset sheet, the "Olympia" has two pairs of 8-in. guns mounted in barbette turrets fore and aft, with 3½ and 4½-in. armor, and a row of five 5-in. guns on each side protected by 4-in. segmental shields. The 5-in. guns are rapid-firing, and the secondary battery comprises 14 6-pdr. and 7 1-pdr. rapid-fire guns, 4 Gatling machine guns and a field gun. Her protective deck has 4¾-in. armor on the side slopes, 2 ins. on the flat over the machinery space, and 3 ins. in front of this space. She has also six torpedo launching tubes, more than any other vessel in the Navy; and additional protection against injury is furnished by coffer-dams filled with 11,-333 cu. ft. of cocoa cellulose.

It will be apparent from the above cursory review that the "Olympia" is a vessel well able to inflict severe blows upon an enemy, to withstand heavy pounding without suffering vital injury, and either to overtake or escape from any but the swiftest ships of war afloat. We may be quite sure that under the capable direction of its gallant commander it gave a good account of itself in the recent conflict.

NOTES FROM THE ENGINEERING SCHOOLS.

Rose Polytechnic Institute.—A course in architecture has been established which will give due prominence to the engineering as well as to the aesthetic side of the subject. The 16th annual catalogue has just been issued, and it gives evidence of steady progress of the Institute. We are glad to note the absence from the catalogue of any reference to a peculiarity which once distinguished the Rose Polytechnic from other engineering schools, viz.: the special prominence given to workshop practice, and the grading of a student's ability by the market value of his work. The workshop is now used strictly for educational purposes, and not with the idea that it is to make skilled machinists.

University of the City of New York.—The school of civil engineering has received from Europe a complete equipment for demonstrating the principle of telegraphy without wires. A private exhibition of the apparatus will soon be given.

Cornell University.—The Summer School, giving courses of instruction for teachers and advanced students, will be held from July 5 to Aug. 13. The courses are open to anyone, on payment of the fees, there being no educational requirements for admission. We note among the courses of especial interest to engineers those in dynamo laboratory practice, in mechanical drawing, in elementary designing, in machine design, and in experimental engineering.

University of Wisconsin.—A large pamphlet, 11 × 15 ins., of 32 pages, containing a reprint of a special number of the Madison "Daily Cardinal," has been issued. It is largely filled with half-tone cuts of the buildings, exterior and interior, and of the beautiful scenery between lakes Mendota and Monona, where the university is located. The views of the interior of the rooms devoted to engineering show a fine equipment. Four engineering courses are given, viz.: Civil, municipal and sanitary, mechanical, and electrical engineering.

University of Virginia.—Summer courses in mathematics and engineering will begin on July 4, and continue for six weeks. The subjects offered comprise trigonometry, calculus, mechanics, strength of materials, graphical statics, and railway and steam engineering. These summer courses have been found useful to students preparing for entrance to the university or other colleges, and to teachers of mathematics in schools and colleges.

ECONOMY TEST OF AN ELECTRIC LIGHTING PLANT IN BALTIMOE, MD.*

This test was made during the summer of 1895, and included a rather careful study of the equipment of one of the central stations for lighting the city of Baltimore, Md. The plant at the time of the test had a capacity of 13,000 16-c. p. incandescent lamps, and 1,420 2,000-c. p. arc lamps. The boiler room contained 9 water-tube boilers with a capacity of 1,750 HP. The engines, 8 in number, aggregating 2,065 HP., were high speed, and of a variety of makes, all being belted to the generators, or jack shafts. The generators were single-phase alternators ranging from 50 to 150 K-W. The arc generators were 60 and 80-light "Wood" machines.

The object of the test was to determine the efficiency of the plant under existing conditions, no effort being made to improve the plant previous to the test. Preliminaries consisted in mapping out methods and calibrating the several instruments. Three tests of 24 hours each were made on different days, the first and third being of the whole plant, the second including three boilers and one engine. Readings were taken every 15 minutes from all instruments simultaneously.

The general results are as follows, and show what may be expected from an ordinary plant under ordinary conditions:

Moisture in coal, %	3.1 to 13.8
Refuse in coal, %	10
Water evaporated per lb. of dry coal from actual temperature and pressure, lbs.	6.48 to 10.1
Equivalent evaporation from and at 212° per lb. of dry coal, lbs.	6.15 " 10.7
Equivalent evaporation from and at 212° per lb. of combustible, lbs.	8.32 " 12.0
Builders' rating above commercial, %	25.7 " 51.8
Moisture in steam, %	.003" 1.24
Rate of combustion per sq. ft. grate surf., lbs	9 5 " 13.8
Water per I. HP., lbs	24.8
Coal per I. HP., lbs	3.04
Efficiency of conversion, arc dynamos, %	61 9 to 66.2
Incandescent dynamos, %	69.0 " 71.0
Station efficiency, %	67.0 " 73.0
Output per lb. of coal, watt-hours	154

*Abstract of a paper by Prof. W. E. Goldsborough, Purdue University, presented at the meeting of the American Institute of Electrical Engineers, April 27.

APPARATUS FOR LETTERING TITLES ON DRAWINGS.

The lettering of a neat title on a drawing requires considerable skill, as well as a large amount of time, and titles uniform in style and neatness, where a number of draftsmen are employed, are difficult to secure. The illustration given herewith represents an apparatus recently introduced to make lettering a mechanical operation. It is known as the "Tampograph" and consists of a set of stencils made of any style or size of alphabet or figures, and a special "tamper" for applying the ink. The stencils are made of a non-corrodible alloy, and are crimped around a wire frame which stiffens them and at the same time is bent up at two places to form handles. Besides the letter or figure six small slots, for use in lining and spacing are cut in each stencil, and are claimed to greatly facilitate the operation. The alphabets of stencils are furnished in sizes ranging from 16-100 in. to 3 ins. in height. Messrs. C. B. Sterling & Co., 120 Liberty St., New York city, are the selling agents for the apparatus.

THE NEW YORK ELECTRICAL EXHIBITION was opened at Madison Square Garden on May 2, in the presence of about 6,000 persons. The exhibition is intended to show the latest developments in the electrical industry and consists of artistically arranged exhibits of various manufacturing and engineering companies. The exhibition is being managed by a company formed for the purpose and will continue during the month of May.

AN EXPERIMENT IN HIGH-VOLTAGE long-distance electric power transmission was recently made at Ogden, Utah, to ascertain the limits within which high voltage currents might be used commercially. The experiment consisted in connecting the Salt Lake ends of the transmission lines together and dividing the transformers at Ogden, normally used for raising the pressure of the current for transmission, into step-up for out-going and step-down for the incoming. This made a complete transmission circuit of 73 miles over three No. 1 B. & S. copper wires. 1,000 HP. was transmitted in this way, the voltage being at times as high as 30,000. The load was composed of three water-tank resistances at the Ogden power house. By careful and repeated experiments with watt-meters at both ends it was shown that this power was transmitted with the loss of only 9%, including 4% loss in the two sets of transformers. The inductance drop was practically nil, the capacity of the line being sufficient to compensate for reactance loss. Using currents at about 24,000 volts, 500 HP. in synchronous motors and lights was operated at Salt Lake City for two days, under most severe climatic conditions, including a thunder storm which continued all one night, causing the lightning arresters to discharge repeatedly. The motors operated during this time without failure and the lights burned without flickering. The experiments were conducted for the General Electric Co., of Schenectady, N. Y., by Mr. F. O. Blackwell.

THE SNOQUALMIE FALLS POWER CO., of Seattle, is developing the power stored in the falls of that name, under Mr. Charles H. Baker, as President. A shaft, 8 × 25 ft., is being sunk in the solid rock at the falls, and will have a depth of 250 ft. to the level of the river below the falls; a tunnel, 15 ft. diameter and 300 ft. long, will meet this shaft at the bottom. Connected with this tunnel will be the chamber for holding the power plant. The general plan of the company is to generate electric power and transmit it to Seattle, Tacoma and intermediate points, the distributing point being Renton, 18.9 miles from the falls. From the power house to Seattle the distance is 30.8 miles, and to Tacoma, 39.8 miles. It is expected to generate 8,000 HP., and figuring upon 20% loss in transmission, the projectors expect to send 6,000 HP. to these cities, or 4,000 to Seattle, and 2,000 to Tacoma. The Chief Engineer of the company is Mr. Thomas T. Johnston, of Chicago, and Mr. James G. Reynolds is the Resident Engineer and Superintendent. Work is now in progress on the shaft and tunnel.

THE LARGEST DROP HAMMER in the world has recently been set up in the drop forging works of the Billings & Spencer Co., Hartford, Conn. The drop weighs 3,000 lbs. and the anvil 90,000 lbs.

AN AUTOMATIC SURVEYING INSTRUMENT has been invented by Mr. John Riddell, of the General Electric Co., Schenectady, N. Y. The device is intended to make an automatic record of the distance and profile of any road or path along which a wheel can be rolled. It consists of a drum actuated by a worm and worm wheel, receiving its motion from the crank shaft of a bicycle, upon which the instrument is supposed to be mounted, through a cord belt. In the interior of the drum is a screw, turned by the same belt, through a train of gears and friction disks, when thrown into action by the change in position of a pendulum. A nut travels on this screw to which is attached the pencil movement used to record the various movements upon a strip of paper wound from a supply spool upon the revolving drum. The action is exceedingly simple. A continuous proportional movement of the drum results from any movement of the bicycle and a raising or lowering of the pencil, due to the pendulum, follows the inclination of the wheel tread upon any incline. The record made is a continuous line, closely following the changing level of the ground passed over.

BOOK REVIEWS.

HOUSE DRAINAGE AND SANITARY PLUMBING.—By Wm. Paul Gerhard, Consulting Engineer for Sanitary Works. Seventh edition. New York: D. Van Nostrand Co., 23 Murray St. Boards; 4×6 ins.; pp. 231; six plates. 50 cts.

This is a new edition, with but few if any changes, of a well-known and handy little volume on house plumbing.

THE JOURNAL OF THE IRON AND STEEL INSTITUTE, No. 2, 1897. Vol. 52. Edited by Bennett H. Brough, Secretary. E. & F. Spon, Limited, London and New York. Cloth; 8vo; pp. 574. $5.

The first half of this volume contains the proceedings of the Cardiff meeting of the Institute. Among the papers read and discussed at that meeting are: "The Application of Traveling Belts to the Shipment of Coal," by Thomas Wrightson; "The Manufacture of Tin Plates," by George B. Hammond; "The Diffusion of Sulphides Through Heat," by E. D. Campbell; "Thermo-Chemical Study of the Refining of Iron," by Professor Honore Ponthiere; "A Spectographic Analysis of Iron Ores and Associated Minerals," by W. N. Hartley and Hugh Ramage; "The Iron Industry of Hungary," by David A. Louis. The second half of the volume contains the usual excellent selection from various periodicals of "Notes on the Progress of the Home and Foreign Iron and Steel Industries."

TRANSACTIONS OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS. Vol. V., 1897.—Edited by the Secretary, Francis T. Bowles, U. S. N., 12 West 31st St., New York. Cloth, 8½ × 11 ins.; pp. 247; 67 plates.

The fifth volume of the "Transactions" gives evidence that the Society of Naval Architects and Engineers is well fulfilling the purposes of its organization. The volume is handsomely printed and illustrated, and the list of members shows a goodly number of names of famous marine engineers. The number of members of the Society is now 326, of associates 203, and of juniors 18. The following is a list of the papers, which, with the discussions upon them, are printed in full in the volume: "Water-Tight Bulkhead Doors," by W. B. Cowles; "Regulations for Loading Vessels," by Lewis Nixon; "Torpedo-Boat Design," by H. G. Gillmor, Asst. Naval Constructor, U. S. N.; "The Commerce of the Great Lakes," by C. C. Wheeler; "Progressive Trials of the 'Guardian,'" by Prof. C. H. Peabody; "Influence of Surface Upon the Performance of Screw Propellers," by Prof. W. F. Durand; "Speed Trials and Experience in Commission of Our New Battleships," by Chief Constructor Philip Hichborn, U. S. N.; "Use of Water Ballast for Colliers in the Pacific Coast Trade," by Hugo P. Frear; "Estimated Weight of Machinery," by Prof. Geo. R. McDermott; "Navy Yard Expenses," by Naval Constructor W. J. Baxter, U. S. N.; "Pneumatic Steering Gear as Applied to the U. S. Monitor "Terror,'" by H. A. Spiller.

ROOFS AND BRIDGES. Part IV.—Higher Structures.—By Mansfield Merriman, Professor of Civil Engineering, Lehigh University, and Henry S. Jacoby, Associate Professor of Bridge Engineering, Cornell University. New York: John Wiley & Sons. Cloth, 6 × 9 ins.; pp. 276; illustrated. Price, $2.50.

Engineers familiar with the previous volumes of this treatise on Roofs and Bridges, will gain a pretty clear idea of the parent volume when we say that the method of treatment of the authors is in all respects the same as in the previous volumes. By "Higher Structures" the authors mean all those structures more complex than simple beams and trusses, which were treated in volume I. and II., including continuous bridges, draw-bridges, cantilever bridges, suspension bridges and arches of various types. Both analytical and graphical discussions are given of these various types of structures, accompanied with examples fully worked out in each case, and brief historical notes on the development of each type. The only lapse from good judgment which we note in the whole volume is the use of the mongrel term "kip" to denote 1,000 lbs. The authors introduce this term as follows in their preface:

As one thousand grammes is a kilogram, which is usually abbreviated into "kilo," so one thousand pounds may be called a kilopound and abbreviated into "kip." Since stresses are now generally computed in thousands of pounds instead of in tons or pounds, a name for the new unit is advantageous, and after using it for several years in the class-room, it is thought best to formally suggest its general adoption.

We would "formally suggest" that engineers should still leave this term to the class-room. There certainly seems to be no need or place for it elsewhere.

THE MARINE STEAM ENGINE.—A Treatise for Engineering Students, Young Engineers, and Officers of the Royal Navy and Mercantile Marine. By the late Richard Sennett, Chief Engineer of the Royal Navy, and Henry J. Oram, Senior Engineer Inspector at the Admiralty. With numerous diagrams. Longmans, Green & Co., London, New York and Bombay. Cloth; 8vo.; pp. 519; 412 illustrations.

The first edition of Mr. Sennett's work on the Marine Steam Engine was published in 1882, and the second edition, with additions and corrections, in 1885. It has now been revised and largely rewritten by Mr. Oram. Mr. A. J. Durston, Engineer-in-Chief of the British Navy, in an introductory note to the present book, states that Mr. Oram has acquired a vast amount of special knowledge and experience of marine machinery of the latest types, and that it is believed that this has been incorporated in the present edition. The numerous advances in marine practice during the past fifteen years, including the introduction of quadruple expansion engines and of water-tube boilers, have created a need for the revision of Mr. Sennett's work, which has long been considered one of the best works on its subject. Mr. Oram's work seems to have been exceedingly well done throughout, and the result is a book which should be considered as part of the necessary outfit of every marine engineer. It should also be of much service to steam engineers on land, since its discussion of general principles are as applicable to land as to marine engines, and since the vertical type of triple and quadruple expansion engines, now almost universally used in marine practice, is rapidly coming into favor in large electric plants and in factories on land. The greater part of the work consists of descriptions of boilers, engines, fittings and attachments, with discussions of their merits and directions for handling, and it is quite easy reading, the difficult mathematical portions being mostly confined to the appendix. The typography is excellent and the illustrations are very clear.

AMERICAN RAILWAY BRIDGES AND BUILDING.—Official Reports of the Association of Railway Superintendents of Bridges and Buildings. Compiled and edited by Walter G. Berg, M. Am. Soc C. E., Prin. Asst. Engr., Lehigh Valley R. R.; Pres. Assoc. Ry. Supts. of Bridge and Buildings. Chicago. B. S. Wasson & Co. Cloth; 8vo.; pp. 706; illustrations, 245. Price, $2.50.

The proceedings of this association are notable for the comprehensive character of the committee reports presented at the annual meetings, these reports being practically treatises on the various subjects; profusely illustrated by examples of individual practice on numerous railways. In this volume are contained the reports presented at the six meetings of 1892 to 1897, inclusive, with the discussions thereon. These discussions give much valuable information supplementing the reports, recording the practice of many roads not mentioned in the reports themselves, and in many cases giving details of cost and construction. The subjects are not classified, but the reports and discussions for each year form a chapter by themselves. The book covers a wide range of subjects. Those relating to constructions include cinder pits, sand and ice plants, turntables, water supply stations and their equipment, bridge floors, stock yards, culverts, station buildings, bridges and trestles, drawbridge locking apparatus, etc. The subjects relating to maintenance include the duties of a superintendent of bridges and buildings, bridge inspection and renewal, repairing washouts and burnouts, etc. There are also important papers on the strength of bridge and trestle timbers.

The book is well printed in large clear type, but a number of the illustrations are very poor, owing in most cases to over-reduction. As a result many of the cuts are black and dirty, where hatching or cross-section lining has run into black patches, while in others the lines are rotten and broken. A serious defect which results from this, is that in many of the cuts the lettering is nearly or quite illegible. This trouble seems to be due in many cases to the cuts having been made from office drawings which were never intended for reproduction in this way, and therefore have lettering of the ordinary size instead of the larger size required where the drawing is to be reproduced on a small scale. The brief and unsystematic index is another defect.

Having noted the most prominent of the good and bad features of the book we may say that the former far outweigh the latter, and that the book is a valuable addition to modern railway literature. It is the first, and only, book dealing specially with the work of the bridge and building department of railway service, and its contents bear strong evidence of the great improvements that are being made in the methods and management of this important department.

THE PURIFICATION OF PUBLIC WATER SUPPLIES.—By John W. Hill, M. Am. Soc. S. E. New York: D. Van Nostrand Co. Cloth; 6½ × 9 ins.; pp. 304; tables and 35 illustrations. $3.

This volume sums up with clearness and force the case against impure water and the remedy for it. The first part of the book is devoted to a discussion of the quality of water supplies and their relation to typhoid fever. There is one chapter entitled "Classification of Cities by Typhoid Statistics," and another made up of "Citations of Typhoid Epidemics." Next come chapters on sedimentation, sterilization and filtration, after which sand and mechanical filters are discussed, a number of American plants of each type being described briefly. Separate chapters describe the foreign filter plants of Hamburg and Berlin respectively, and still another chapter is devoted to the Fischer system of filtering through artificial stone slabs at Worms, and the Anderson iron process. The proposed filters for Cincinnati, O., as planned by the special water commission a few years ago, are described. The final chapter is on "Cost of Filters and Filtration." There are three appendices, as follows: "Typhoid Fever Statistics from Large Cities of the World," being for the seven years, 1890 to 1896, inclusive; "The Bacteria," being a brief but comprehensive description of that organism, and "The Legal Liability of Cities and Water Companies for Damages by Sewage Polluted Water." Most of the illustrations show the details of construction of various filter plants.

Nearly all the comments to be made on this book are favorable. A few misleading statements have been noticed, although in some instances the context rectifies these. On p. 133 it is stated that "all sand filters are therefore intermittent filters, none work continuously." The "therefore" here refers to the fact that all filters must sometimes be stopped for cleaning, and when so stopped a new supply of air or oxygen is drawn into the pores of the sand, but this is merely incidental. The fact is that nearly all the slow sand filters in the world are operated on the continuous plan, the water carrying enough free oxygen to maintain the material efficiency of the filter.

From the title to the cut on p. 159, and from a statement on p. 203, it might be inferred that St. Louis and New Orleans, respectively, have filter plants, but such is not the case.

Exception may be taken to the statement on p. 184, that: "The mechanical filter, so called, is mechanical only so far as machinery operated by power is applied for the raking and agitation of the sand while being cleansed, and for the regular dosing of the applied water with the alum solution. The process of filtration, excepting as the flocculent alum precipitate may affect it, is altogether natural."

This statement is not broad enough. Aside from being mechanical by virtue of the use of machinery, these filters are fundamentally so in another sense of the word, for their principal object is to remove suspended matter by the purely physical or mechanical process of straining it out. Slow sand filtration is also mechanical in this second use of the word, while it relies, in addition, upon chemical and bacterial action for the work of purification.

The author states that the efficiency of filtration should be judged by the reduction of typhoid fever in the community supplied by the filtered water rather than by its effect upon the number of bacteria in the applied water. He even suggests that contract guarantees should be based on the reduction of typhoid rather than upon the percentage of bacteria removed. To this it may be answered that private wells, the milk supply and other causes over which the contractor has no control, are often the cause of much typhoid fever and of numerous epidemics. Besides this, frequent bacterial examinations show what a filter is doing from day to day, while the lessons to be drawn from typhoid statistics are far more remote in point of time, showing what has been rather than what is.

Another principle laid down in the book is that "the efficiency of a filter for hygienic purposes should be measured altogether by its worst results, and not by the best or even the average results." This is of course largely true, but in practice cannot be accepted too literally, unless "worst results" be construed somewhat liberally.

The last two points of criticism illustrate a tendency of the author, happily stronger in the past than now, to insist upon a standard of quality for public water supplies so near perfection as to strongly tend to defeat his very sincere and laudable desire to reduce to the minimum the spread of typhoid fever by means of impure water. High ideals are not only praiseworthy but necessary if we are to advance in either morality or science, but many good intentions and high endeavors have failed of fulfilment because of strenuous insistence on absolute and continuous achievements of arbitrary standards. At one time Mr. Hill was inclined to insist on nothing short of combined filtration and distillation of all water used for drinking and similar purposes, the water so treated to be distributed through a separate system of street and house pipes. In the present volume the author states, after giving an estimate of the cost of such a supply:

It is probable that now a system of double water supply is rather too refined for most municipal corporations, but it is possible that such may be demanded by future generations.

We are much pleased to note this change to a more practical plane on the part of the author, and think the usefulness of his book will be much greater as it stands than if he had adhered more strictly to his earlier ideas. The present volume will lead no one to give up in despair the attempt to secure pure water because perfection cannot be obtained at a reasonable cost. It makes perfectly obvious the value of pure water and the comparative ease and light cost of securing a fairly high standard of purity.

To the contents of the book as a whole we are glad to accord high praise. We also extend our good opinion to the work as a piece of most excellent book-making, in typography, illustrations, presswork and binding.

In closing, we regret that we are compelled to say that the book has, like so many others, a defective index. The first five lines of the index are sufficient to illustrate this point, three of them having as catch words "action" and two "advantage." Some, at least, of these and similar entries are not cross-indexed. We do not think that any one in search of information regarding sedimentation would ever look for it under the word advantage. The natural place for it is, of course, under sedimentation. This particular reference might just as well be put under value of sedimentation as under advantages of sedimentation, but it is equally useless under either.